Litton

MODEL 3461A

AC/OHMS CONVERTER-
DC PREAMPLIFIER

OPERATING AND SERVICE MANUAL

HEWLETT PACKARD

OPERATING AND SERVICE MANUAL

-hp- Part No. 03461-90000

MODEL 3461A

AC/OHMS CONVERTER-
DC PREAMPLIFIER

Serials Prefixed: 705-, 740-

P.O. Box 301, Loveland, Colorado, 80537 U.S.A.

IMPORTANT

These instructions are supplied to permit earliest possible delivery of your instrument. Additional information will be included in a complete manual.

To receive your copy of the complete Operating and Service Manual when it is available, fill out, detach, and return the self-addressed card below (no postage necessary, when mailed in the United States).

Type or print your full name and address in the spaces provided. Be sure to enter the full serial number of the instrument. The card will be used as a "window" address card in order to be sure the manual reaches the proper person. The final manual will not be shipped until the address card is received.

Fill out and mail **now**; no postage required in U.S.A.

5951 0109

CAUTION

KEEP THE INSIDE OF THE INSTRUMENT CLEAN, ESPECIALLY INSIDE THE GUARD. LEAKAGE PATHS DUE TO DUST OR FINGER PRINTS ON COMPONENTS OR CONNECTORS WILL DEGRADE THE INSTRUMENT ACCURACY. REMOVE THE COVERS ONLY FOR MAINTENANCE.

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3461A SPECIFICATIONS

AC CONVERTER

Ranges, each with 20% overrange capability:

1 V, 10 V, 100 V, 1000 V

Frequency range

AC Normal: 50 Hz to 100 kHz
AC Fast: 200 Hz to 100 kHz

Accuracy relative to a 5 mA thermocouple calibrated by the National Bureau of Standards over temperature range of +20°C to +30°C for 90 days

50 Hz to 100 Hz: ±(0.08% of reading + 0.015% of full scale)
100 Hz to 10 kHz: ±(0.06% of reading + 0.01% of full scale)
10 kHz to 20 kHz: ±(0.08% of reading + 0.015% of full scale)
20 kHz to 100 kHz: ±0.15% of reading or ±0.10% of full scale, whichever is greater error.

Temperature coefficient of accuracy from 0°C to + 50°C:

±(0.002% of reading + 0.0005% of full scale) per degree centigrade

Long-term stability in temperature range of +20°C to +30°C with < 50% relative humidity for 6 months:

±(0.05% of reading + 0.01% of full scale), 50 Hz to 100 kHz

Response time required for output to be within 0.1% of full scale of final value after a step change of input voltage

ACN: 1.0 sec
ACF: 400 msec

Input impedance

front panel: 5 MΩ ±0.1% in parallel with approx 40 pF at panel terminals on all ranges
rear panel: 5 MΩ ±0.1% in parallel with approx 75 pF at panel terminals on all ranges

Converter output voltage:

0 to + 1.0 Vdc full scale each range (+1.2 V at max overrange)

Output resistance:

220 kΩ ±2%

DC PREAMPLIFIER

Ranges, each with 20% overrange capability:

.1 V, 1 V, 10 V

Absolute accuracy over temperature range of +20°C to +30°C for 90 days after calibration, assuming occasional adjustment of front panel ZERO

.1 V range: ±(0.004% of reading + 0.001% of full scale)
1 V, 10 V ranges: ±(0.002% of reading + 0.001% of full scale)

Temperature coefficient of absolute accuracy from 0°C to +50°C

.1 V range: ±(0.0002% of reading + 0.0001% of full scale) per degree centigrade
1 V, 10 V ranges: ±(0.0001% of reading + 0.0001% of full scale) per degree centigrade

Long-term stability in temperature range of +20°C to +30°C with < 50% relative humidity for six months

.1 V range: ±(0.008% of reading + 0.001% of full scale)
1 V, 10 V ranges: ±(0.002% of reading + 0.001% of full scale)

Zero stability in temperature range of +20°C to +30°C with < 50% relative humidity for 90 days:

±3.0 μV

Temperature coefficient of zero stability from 0°C to +50°C:

±0.1 μV per degree centigrade

Noise in temperature range of +20°C to +30°C:

3.0 μV peak-to-peak maximum

Input resistance:

greater than 10^{10} Ω

Output voltage

.1 V, 1 V ranges: 0 to +1.0 V dc full scale (+ 1.2 V at max overrange)
10 V range: 0 to + 10 V dc full scale (+ 12 V at max overrange)

Output resistance:

less than 1 Ω

OHMS CONVERTER

Ranges, each with 20% overrange capability:

1 kΩ, 10 kΩ, 100 kΩ, 1 MΩ, 10 MΩ

Absolute accuracy over temperature range of $+20^{\circ}C$ to $+30^{\circ}C$ for 90 days after calibration

1 kΩ thru 100 kΩ ranges: ±(0.008% of reading + 0.002% of full scale)
1 MΩ, 10 MΩ ranges: ±(0.012% of reading + 0.002% of full scale)

Temperature coefficient of absolute accuracy from $0^{\circ}C$ to $+50^{\circ}C$

1 kΩ thru 100 kΩ ranges: ±(0.0005% of reading + 0.0001% of full scale) per degree centigrade
1 MΩ, 10 MΩ ranges: ±(0.001% of reading + 0.0001% of full scale) per degree centigrade

Long-term stability in temperature range of $+20^{\circ}C$ to $+30^{\circ}C$ with < 50% relative humidity for 6 months:

±(0.01% of reading + 0.002% of full scale)

Input characteristics:

lead resistance up to 9 Ω per lead rejected from measurement

Source current (red SIGNAL terminal pos; black SIGNAL terminal neg)

1 kΩ range: 1 mA
10 kΩ range: 100 μA
100 kΩ range: 10 μA
1 MΩ, 10 MΩ ranges: 1 μA

Converter output voltage

1 kΩ thru 1 MΩ ranges: 0 to + 1.0 V dc full scale (+1.2 V at max overrange)
10 MΩ range: 0 to + 10.0 V dc full scale (+12 V at max overrange)

Output resistance

less than 1 Ω

GENERAL INSTRUMENT

Bypass relay permits ranging over five ranges on the DC function without changing input terminals by supplementing the .1 V thru 10 V range capability of the Preamplifier with the 100 V and 1000 V ranges of the 3460B, and also allows direct use of all four 3460B ranges at the same terminals on a separate Bypass function.

Selection of range and function at front-panel pushbuttons, or at rear-panel Remote Control Cable by grounding wires.

Selection of front or rear input at front-panel switch

Isolation parameters

input: Floating and guarded. Guard may be operated up to ± 500 Vdc with respect to instrument chassis (power line ground), and Low up to ± 50 Vdc with respect to Guard.

common-mode rejection: 160 dB at dc and 120 dB at 60 Hz with < 1 kΩ between Low and Guard

Power at 115 V or 230 V ±10%, 50 to 60 Hz: approximately 30 watts

Dimensions: 16-3/4" wide; 3-3/8" high; 18-3/8" deep

Weight: Net 24 lbs (10.8 Kg); shipping 37 lbs (16.7 Kg)

3461A - 3460B SYSTEM CONSIDERATIONS

Accuracy specification of 3460B must be added to that of 3461A

absolute accuracy: ±(0.004% of reading + 0.002% of full scale)
temperature coefficient of absolute accuracy: ±(0.0002% of reading + 0.0001% of full scale)
long-term stability: ±(0.008% of reading + 0.002% of full scale)

Maximum reading rate

ac measurements
- ACN: 1 reading/sec
- ACF: 2 readings/sec

dc measurements (requires external triggers)
- .1 V, 1 V ranges: 6.5 readings/sec
- 10 V thru 1 kV ranges: 15 readings/sec

ohms measurements (requires external triggers)
- 1 kΩ thru 1 MΩ ranges: 6.5 readings/sec
- 10 MΩ range: 15 readings/sec

Auto-ranging time per range change

ac measurements
- ACN: 1.0 sec
- ACF: 500 msec

dc, ohms measurements: 33 msec

Polarity selection time: insignificant

All control may be accomplished through 3461A rear panel Remote Control Cable

Resolution

ac measurements: 10 μV on 1 V range
dc measurements: 1 μV on .1 V range
ohms measurements: .01 Ω on 1 kΩ range

Isolation parameters

input: Floating input and guarding are conserved for system. Same max voltages between Low and Guard and ground as for 3461A

common-mode rejection: 6 dB less than for 3461A alone

Response:

reads within specified accuracy for each trigger coincident-with or proceeding a step input voltage change on any range

DC input resistance

DC function
.1 V thru 10 V ranges: $\geq 10^{10}\ \Omega$
100 V, 1 kV ranges: $10^{7}\ \Omega \pm 0.03\%$

Bypass function
1 V, 10 V ranges: $> 10^{10}\ \Omega$ continuously if input voltage does not change by more than 6% between readings; but $> 10^{10}\ \Omega$ only during 2nd sample and $10^{7}\ \Omega$ otherwise if input voltage does change between readings. Continuous $10^{7}\ \Omega$ may be programmed.

100 V, 1 kV ranges: $10^{7}\ \Omega \pm 0.03\%$

SECTION I

GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. 3460B Compatibility.

1-3. The Standard Model 3461A AC/Ohms Converter, DC Preamplifier is a mate to the Option 02 or 03 3460B DC Digital Voltmeter. As a system, the 3461A-3460B combination offers remote programming and automatic ranging on all measurement functions. The 3460B is slaved to the 3461A so that the proper decimal location, actual measurement range, and function display of the 3460B are controlled by the logic circuitry of the 3461A. In turn, the 3460B autoranges the 3461A. Complete system control, including selection of function, range, and 3460B sample-period modifications may be programmed through the rear-panel 3461A Remote Control Jack. Also, 3460B reading-rate triggers may be applied through the 3461A RC Jack. From the front panel, the function and range may be selected at the 3461A, and the rate of automatic reading triggers may be adjusted at the 3460B.

1-4. Accuracy.

1-5. The 3461A is adjusted at the factory to have the accuracy specified. Procedures are given in Section V to check these, and to readjust at 90 day intervals. The calibration uncertainty for the AC Converter is a major fraction of the stated accuracy, as noted by the smaller error given for the long term stability of six months. Therefore, the 90 day stability of the AC Converter is significantly better than the accuracy specification.

1-6. As to the accuracy of the system, the specifications of the two instruments must be added. Thus for an ohms measurement on the 10 kΩ range, the sum of the two absolute accuracies is ±(0.012% of reading + 0.004% of full scale). This means that the resistance indicated will not be in error of the legal absolute value by greater or less than the sum of 0.012% of the indicated value plus 0.004% of the full scale value 10 kΩ. For air temperatures outside the calibration range, the temperature coefficient of accuracy must be added to the accuracy specification. In an air temperature of 32°C for instance, the value ±2 x (0.0007% of reading + 0.0002% of full scale) must be added on, resulting in an aggregate accuracy of ±(0.0134% of reading + 0.0044% of full scale) for the 10 kΩ range at 32°C.

1-7. Operation Particulars.

1-8. The AC Converter is average responding, but calibrated for rms use. All four ranges generate + 1 V dc for a full scale input, and are calibrated into the 10^7 Ω input resistance of the 3460B. An AC Fast mode provides faster transient response for signal frequencies above 200 Hz.

1-9. Four-terminal measurements are possible with the Ohms Converter, whereby lead resistance up to 9 Ω per lead is rejected from the measurement. The source current is 1 mA, 100 μA, and 10 μA respectively for the 1 kΩ thru 100 kΩ ranges; and 1 μA for the 1 MΩ and 10 MΩ ranges. The converted output voltage is + 1 V dc at full scale on the 1 kΩ thru 1 MΩ ranges, and + 10 V dc on the 10 MΩ range.

1-10. A DC Preamplifier is incorporated to provide X10 gain for a .1 V range capability of high input resistance when used in conjunction with the 1 V range of the 3460B. Unity gain on the 1 V and 10 V ranges provides equally high input resistance of $> 10^{10}$ Ω. A bypass relay configuration allows the 100 V and 1000 V ranges of the 3460B to be selected on the same DC function to accompany the three Preamplifier ranges. This allows auto-ranging over fine dc ranges, .1 V thru 1000 V. The Preamplifier output resistance is less than 1 Ω.

1-11. A separate Bypass function may be selected that allows direct use of all four 3460B ranges with negligible additional error over that of the 3460B alone.

1-12. OPTION INSTRUMENTS.

Four Options of the 3461A are available, 01 thru 04, which are minus one or more of the AC, DC, and Ohms functions of the Standard instrument. A Bypass function, which enables direct use of the four 3460B ranges through the input connectors of the 3461A, is included in all Options. Plug-in kits enable the addition of the remaining functions to Option instruments. However, there is one restriction to the combinations of functions that may be added: The Ohms function alone cannot be added to Option 02 — the DC Preamplifier must be added as well because the Ohms conversion process utilizes the DC Preamplifier.

OPTION INSTRUMENTS

01 - DC Preamplifier

02 - AC Converter

03 - DC Preamplifier and Ohms Converter

04 - DC Preamplifier and AC Converter

PLUG-IN KITS

AC Converter	- 11087A
DC Preamplifier	- 11088A
Ohms Section	- 11089A

1-13. INSTRUMENT/MANUAL IDENTIFICATION.

Hewlett-Packard uses a two-section eight-digit serial number (000-00000). If the first three digits of the serial number on the rear panel of your instrument are not the same as those on the title page of this manual, then a Manual Changes supplement will describe any differences between your instrument and the Model 3461A of this manual.

1-14. EQUIPMENT.

Table 1-1 lists the equipment supplied with each instrument. Part numbers are given for individual purchase. The Rack Mounting Kit also contains three maintenance assembly-extenders.

Rear Input Volts Cable	11065A
Rear Input Ohms Cable (Std and 03 only)	11090A
Output Cable	11091A
Interface Logic Cable	11092A
Remote Control Cable	11093A
Rack Mounting Kit	03461-84401
Maintenance assembly-extenders	
15 pin	5060-6033
20 pin	5060-6032
22 pin	5060-0630
Power Cord	8120-0078
Operating and Service Manual	03461-90000

Table 1-1. Equipment Supplied

SECTION II

INSTALLATION

2-1. This section contains installation and shipping information.

2-2. INITIAL INSPECTION.

Each 3461A has been carefully inspected prior to shipment and should be in perfect electrical order and without mars or scratches. To confirm this, the instrument should be inspected upon receipt for damage that might have occurred in transit, or for deficiencies otherwise. If there is damage due to shipping, file a claim with the carrier; if there are electrical or mechanical deficiencies not attributable to shipping, then refer to the statement of warranty on the inside rear cover of this manual. Use the procedures of Section V to check instrument performance. Refer to Section I for the list of equipment supplied.

2-3. POWER REQUIREMENTS.

The Model 3461A must be operated from either a 115 volt or 230 volt source ($\pm$10%) having a frequency between 50 Hz and 60 Hz. Power dissipation is less than 35 watts for the Standard instrument.

CAUTION

TO AVOID INSTRUMENT DAMAGE, THE REAR PANEL LINE VOLTAGE SWITCH MUST BE IN THE CORRECT POSITION BEFORE POWER IS APPLIED.

2-4. GROUNDING REQUIREMENTS.

For the safety of operating personnel, a provision for grounding the instrument case has been provided as recommended by the National Electrical Manufacturer's Association (NEMA). The offset pin of the power cable grounds the instrument when the appropriate receptacle is used. If only a two-contact receptacle is available, use a three-prong-to-two-prong adapter and connect the gain pigtail of the adapter to earth ground.

2-5. ENVIRONMENTAL REQUIREMENTS.

The operating requirements are $0^{o}C$ to $+50^{o}C$ ambient temperature and $<$ 90% relative humidity; but the instrument may be stored between $-40^{o}C$ and $+75^{o}C$. No special cooling is required.

2-6. INSTRUMENT MOUNTING.

2-7. Bench Use.

The front of the instrument may be elevated for operating convenience by lowering the tilt stand. The plastic feet are shaped for setting atop the companion -hp- 3460B Digital Voltmeter.

2-8. Rack Use.

If the instrument is to be rack mounted, add the brackets supplied to each end of the front panel and provide additional means of support at the rear.

2-9. INTERCONNECTION WITH 3460B DIGITAL VOLTMETER.

If the 3461A is to be used with the -hp- 3460B Digital Voltmeter, the following rear-panel interconnections and 3460B switch settings are necessary:

a. The Interface Logic Cable is connected between the 3461A INTERFACE LOGIC Jack and the 3460B REMOTE CONTROL Jack, and the Output Cable between the 3461A OUTPUT Jack and the 3460B INPUT Jack.

b. REMOTE RANGE and REAR INPUT are selected at the 3460B front-panel.

2-10. REPACKAGING FOR SHIPMENT.

2-11. If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument describing the work to be accomplished and identifying the owner and instrument. Identify the instrument by serial number, model number, and name in any correspondence. If you have any questions, contact your local Hewlett-Packard Sales and Service Office. See Appendix B for office locations.

2-12. If the original shipping container is to be used, place instrument in container with appropriate packing material and seal the container well with strong tape or metal bands. A new container may be purchased from your nearest -hp- Sales and Service Office.

2-13. If the original container is not to be used, then use a heavy carton or wooden box with an inner container. Wrap the instrument with heavy paper or plastic and protect the face with cardboard strips before placing in the inner container. Use packing material around the outside of the inner container and instrument on all sides, and seal the outer container well with strong tape or metal bands. Mark the shipping container with "DELICATE INSTRUMENT," or "FRAGILE."

SECTION III

OPERATING INSTRUCTIONS

3-1. Section III contains the procedures and data necessary to operate the 3461A-3460B system.

3-2. CONTROLS, INDICATORS, AND CONNECTORS.

The front and rear panel controls, indicators, and connectors are identified on Pages 3-2 thru 3-4.

3-3. INSTRUMENT INTERCONNECTION AND TURN-ON.

To operate the 3461A and 3460B as a system to measure ac and dc voltage and resistance, the following control selections and rear-panel interconnections are necessary:

a. The Interface Logic Cable is connected between the 3461A INTERFACE LOGIC Jack J54 and the 3460B REMOTE CONTROL Jack J27; the Output Cable between the 3461A OUTPUT Jack J53 and the 3460B INPUT Jack J26.

b. REMOTE RANGE and REAR INPUT are selected at the 3460B front-panel.

c. The Line-Voltage Switch of each instrument is positioned to the power line voltage of 115 V or 230 V. Line voltage may vary ±10%.

d. The 3460B V/F CHECK switch is placed at center position.

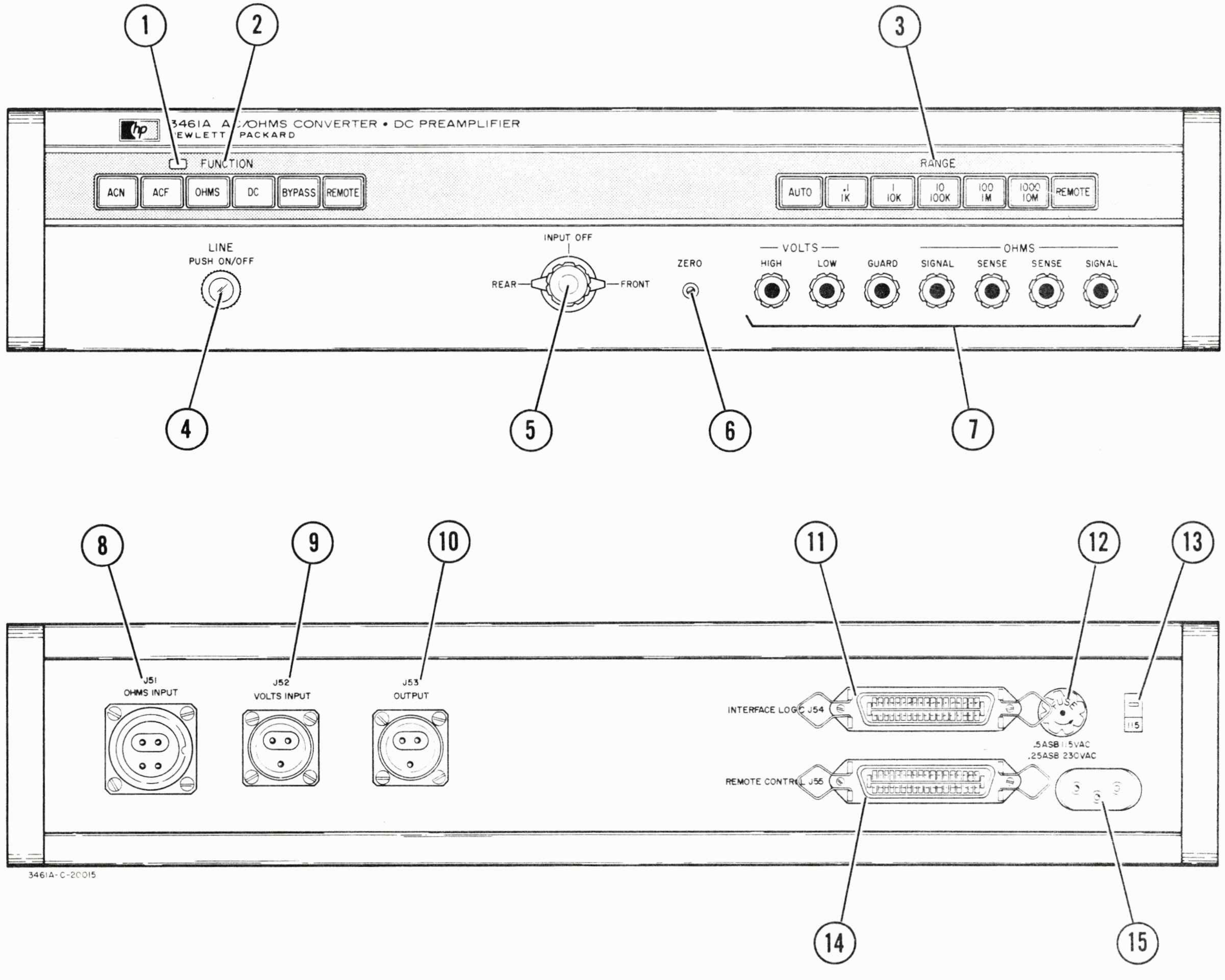
e. Turn-on is at the 3461A LINE pushbutton, and at the 3460B LOCAL/REMOTE control.

3-4. FUNCTION SELECTION.

3-5. DC, Ohms, AC Normal, AC Fast, and Bypass functions are selected by either depressing the appropriate pushbutton or by depressing REMOTE (FUNCTION) and grounding the appropriate wire of the 3461A Remote Control Cable. The wire for Bypass must be held at ground; whereas, the others need be grounded only momentarily. Should a function be selected that is not included in an Option instrument, the "NO" Indicator will signify. If more than one FUNCTION button is depressed, the one on the right rules.

3-6. The 3460B visual readout displays "AC" for AC Normal and AC Fast functions; "KΩ" or "MΩ" for Ohms function; and "+" or "-" for DC and Bypass functions. Refer to the 3460B Operating and Service Manual for the function code of the recorder readout.

3-7. AC Fast allows a higher reading rate (2/sec max) for frequencies above 200 Hz. AC Normal must be selected for frequencies below 200 Hz.


1
2
3
3461A AC/OHMS CONVERTER • DC PREAMPLIFIER
HEWLETT PACKARD
FUNCTION
ACN
ACF
OHMS
DC
BYPASS
REMOTE
RANGE
AUTO
.1 1K
1 10K
10 100K
100 1M
1000 10M
REMOTE
LINE
PUSH ON/OFF
INPUT OFF
REAR
FRONT
ZERO
VOLTS
HIGH
LOW
GUARD
OHMS
SIGNAL
SENSE
SENSE
SIGNAL
4
5
6
7
8
9
10
11
12
13
J51
OHMS INPUT
J52
VOLTS INPUT
J53
OUTPUT
INTERFACE LOGIC J54
FUSE
.5ASB 115VAC
.25ASB 230VAC
115
REMOTE CONTROL J55
3461A-C-20015
14
15

CONTROLS, INDICATORS, CONNECTORS

(1) "NO" Indicator illuminates when a function not installed in an Option instrument is selected, or when the .1 V range is selected on ACN, ACF, or Bypass function.

(2) FUNCTION pushbuttons select individual functions or REMOTE control of function.

(3) RANGE pushbuttons select individual ranges, AUTOmatic ranging, or REMOTE control of range.

(4) LINE pushbutton is turn-on switch.

(5) FRONT/REAR switch selects front-panel binding posts or rear-panel jacks as input connectors, or shorts to Guard the inputs of the DC Preamplifier and AC and Ohms Converters when INPUT OFF is selected.

(6) ZERO adjustment is for the DC Preamplifier.

(7) Input binding posts are selected by FRONT/REAR switch in FRONT position. HIGH and LOW are for all functions except Ohms; SENSE and SIGNAL are for Ohms. GUARD is for all functions.

(8) (9) OHMS INPUT Jack J51 and VOLTS INPUT Jack J52 are selected by FRONT/REAR switch in REAR position.

(10) OUTPUT Jack J53 is for interconnection of 3461A output voltage to rear INPUT of 3460B.

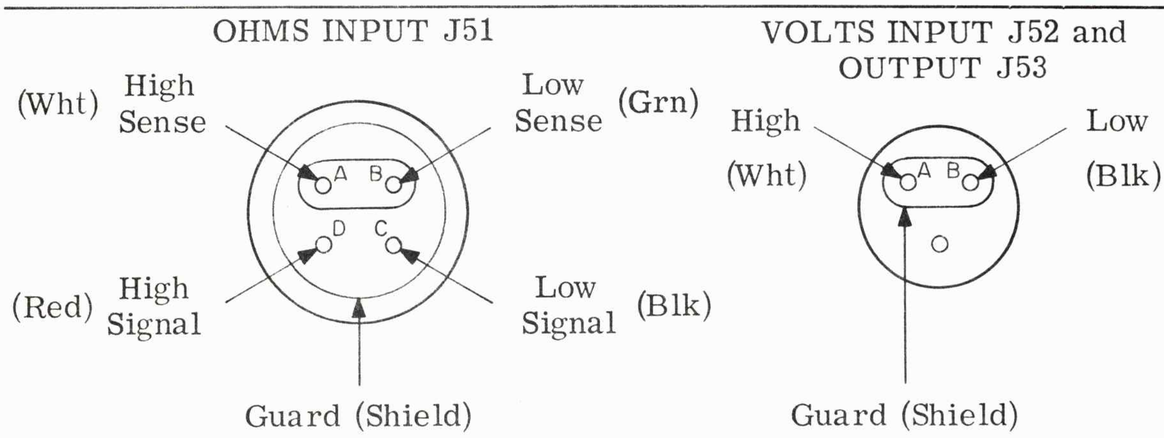
(11) INTERFACE LOGIC Jack J54 is for interconnection of logic signals between 3461A and 3460B.

(12) FUSE provides instrument protection. 115 V operation: 1/2 A, S.B., 2110-0008. 230 V operation: 1/4 A, S.B., 2110-0018.

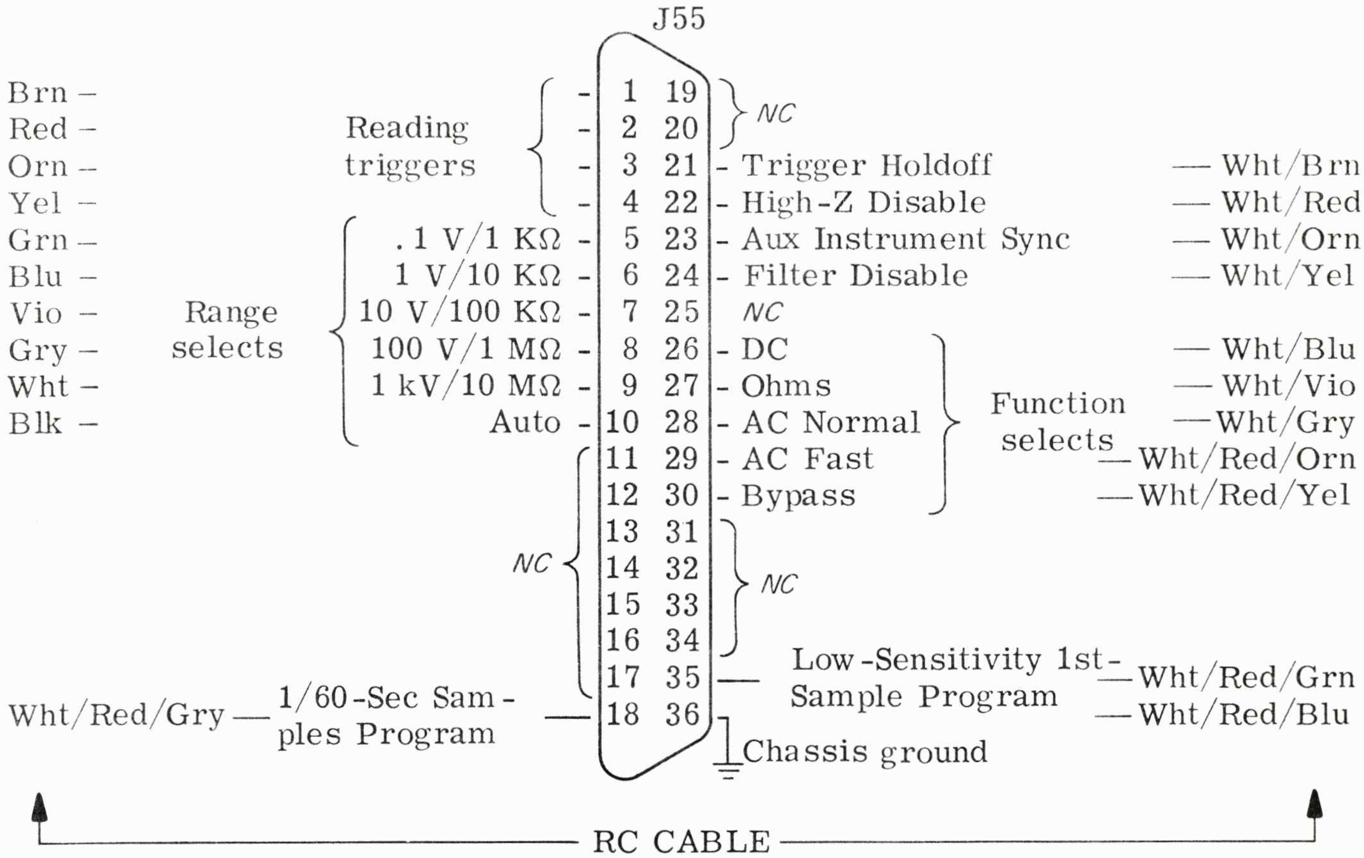
(13) Line Voltage Switch selects proper line voltage of 115 V or 230 V ac.

(14) REMOTE CONTROL Jack J55 is for remote control of 3461A-3460B System function, range, reading rate, sample length, and high-Z input.

(15) Power input connector.



REMOTE CONTROL JACK



Pin 1 - Pos. going, around zero level.
Pin 2 - Neg. going, around zero level.
Pin 3 - Pos. going, not exceeding 200 V level.
Pin 4 - Neg. going, not exceeding 200 V level.

(Pins 1–4:) Apply 20 V p-p pulses to trigger 3460B to read 3461A output.

Pins 5 thru 10 - Connect to pin 36 to select range.

Pin 18 - Connect to pin 36 to program both samples of 3460B readings to be 1/60 sec duration on the 10 V thru 1 kV DC and Bypass ranges and 10 MΩ range.

Pin 21 - Apply a dc voltage of + 3 V to + 10 V relative to pin 36 to prohibit the 3460B from taking readings even when remotely triggered.

Pin 22 - Connect to pin 36 to prohibit high-Z input on the 1 V and 10 V Bypass ranges.

Pin 23 - Use these reading-rate pulses to synchronize auxiliary equipment.

Pin 24 - Connect to pin 36 to exclude the 3460B Input Filter on Bypass function.

Pins 26 thru 30 - Connect to pin 36 to select measurement function.

Pin 35 - Connect to pin 36 to program 1st sample of 3460B readings to be a low sensitivity measurement for 1/60 sec. (A voltage change between readings accomplishes essentially the same thing.)

3-8. DC and Bypass functions are selected according to range and input resistance requirements. DC function employs a Preamplifier to add a .1 V range to the 1 V thru 1000 V ranges of the 3460B, and to maintain a continuous high-Z input (> 10^{10} Ω) on the 1 V, 10 V, and added ranges. Bypass function relies on the 3460B alone, where only the 1 V and 10 V ranges have continuous high-Z, and only if there is little change of input voltage per reading.

3-9. RANGE SELECTION.

Individual ranges are selected by depressing the appropriate 3461A pushbutton or by depressing REMOTE (RANGE) and grounding the appropriate wire of the 3461A Remote Control Cable. Automatic ranging is selected by depressing AUTO, or by depressing REMOTE (RANGE) and grounding wire 10 of the Remote Control Cable. "NO" will illuminate if the .1 V range on ACN, ACF, or Bypass is selected. If more than one RANGE button is depressed, the one on the right rules. The range of the 3461A, whether selected locally, remotely, or automatically is reflected in the 3460B readout by automatic placement of the decimal point.

3-10. PROGRAMMING.

3-11. 3460B Sample-Period Alterations.

3-12. Grounding of wire 18 and/or wire 35 of the 3461A RC Cable, and also changes of input voltage, affect the sample length (two samples per reading), the input resistance, and the input sensitivity. In turn, the reading rate and superimposed noise rejection are affected.

3460B SAMPLE LENGTH

1 V thru 1 kV AC
.1 V, 1 V DC
1 V Bypass
1 kΩ thru 1 MΩ

	1st Samp	2nd Samp
< 6%*	1/10 sec	1/10 sec
> 6%* or Pin 35	1/60 sec**	1/10 sec

10 V thru 1 kV DC
10 V thru 1 kV Bypass
10 MΩ

	1st Samp	2nd Samp
< 6%*	1/10 sec	1/10 sec
> 6%* or Pin 35	1/60 sec**	1/10 sec
Pin 18	1/60 sec	1/60 sec
Pin 18 plus either > 1%* or Pin 35	1/60 sec**	1/60 sec

* % full scale input voltage change per reading

** Low-sensitivity sample

J55 pin 18 grounded = 1/60 Sec Samples

J55 pin 35 grounded = Low-Sensitivity 1st-Sample

Table 3-1. 3460B Sample Length

3-13. Wire 18 grounded (1/60 Sec Samples) causes both samples on the 10 V thru 1000 V DC and Bypass ranges and 10 MΩ range to be 1/60 sec duration rather than the normal 1/10 sec. This allows a higher possible reading rate but decreased superimposed noise rejection.

3-14. Wire 35 grounded (Low-Sensitivity 1st-Sample) or a 6% or 1% * change of input voltage causes the 1st sample to be a low sensitivity measurement for 1/60 sec. The 2nd sample remains 1/10 sec. If Low-Sens 1st-Samp is not programmed and if there is less than the aforementioned voltage change, the 3460B assumes a "quiescent" mode whereby it measures only the small voltage change each reading instead of making a "total" measurement each time. Both samples are then identically performed for 1/10 sec with high input sensitivity.

3-15. DC, Bypass Input Resistance.

3-16. The Preamplifier provides an input resistance of greater than 10^{10} ohms on the .1 V thru 10 V ranges of the DC function; whereas the 3460B itself provides the input resistance on the top two DC ranges and four Bypass ranges. The 3460B has 10^7 Ω input resistance on the 100 V and 1000 V ranges, and either continuous high-Z (> 10^{10} Ω) or high-Z only during the 2nd sample on the 1 V and 10 V ranges. The programming of Low-Sens 1st-Samp or an input voltage change of 6% of full scale (1% of full scale on 10 V range if 1/60 Sec Samples is programmed) drops the input resistance on Bypass function to 10^7 Ω except during the 2nd sample. However, this lowered input resistance during the 1st sample causes no greater loading error than with continuous high-Z because the 2nd sample corrects the 1st.

3-17. The change from > 10^{10} Ω to 10^7 Ω occurs even when the 3460B is on HOLD if the input voltage changes after the last reading. But Low-Sens 1st-Samp causes this resistance change only if it is programmed sometime before the end of a reading.

BYPASS HIGH-Z CONDITIONS

	1 V Range	10 V Range
Continuous High Z	< 6%*	< 6%* or < 1%* and Pin 18
High Z 2nd Samp Only	> 6%* or Pin 35	> 6%* or Pin 35 or > 1%* and Pin 35

* % Full scale input voltage change per reading.

J55 pin 18 grounded = 1/60 Sec Samples.

J55 pin 35 grounded = Low-Sensitivity 1st-Sample.

Table 3-2. Bypass High-Z Conditions

* See Table 3-2.

3-18. Superimposed Noise Rejection.

Superimposed noise rejection on dc and ohms measurements is due strictly to the integration technique of the 3460B and the Input Filter of the Model 3460BF. Rejection is greatest when the 2nd sample is 1/10 sec (rather than 1/60 sec), and the Input Filter is not programmed out at the RC Cable. The 2nd sample is always 1/10 sec on the .1 V and 1 V DC ranges, 1 V Bypass range, and 1 kΩ thru 1 MΩ ranges. Both samples may be programmed to 1/60 sec on all other ranges for the purpose of a higher reading rate, but at the expense of less noise rejection. The filter may also be programmed out.

3-19. READING RATE.

Measurements of the 3461A output voltage by the 3460B are initiated by internal triggers at a rate adjustable by the RATE control when the control is off HOLD. Single triggers are possible when RATE is on HOLD by successively depressing the TRIGGERING pushbutton or by applying voltage pulses to the 3461A RC Jack. Table 3-3 lists the maximum possible reading rates as a function of range, measurement function, programming of 1/60 Sec Samples and/or Low-Sens 1st-Samp, and the percentage of full scale change of the measured voltage (or resistance) between readings. External triggering is required for the higher rates. A trigger Holdoff line of the RC Cable may be held at a voltage between + 3 V and + 10 V to prohibit the 3460B from taking readings even while it is being triggered.

MAXIMUM READING RATE

.1 V, 1 V DC
1 V Bypass
1 kΩ thru 1 MΩ

< 6%*	4.5/sec
> 6%* or Pin 35	6.5

10 V thru 1 kV DC
10 V thru 1 kV Bypass
10 MΩ

< 6%*		4.5/sec
> 6%* or Pin 35		6.5
Pin 18	> 1%*	14
Pin 18	< 1%* or Pin 35	15.5

1 V thru 1 kV AC

	ACN	ACF
< 6%*	1/sec	1.5/sec
> 6%* or Pin 35	1	2

* % Full scale input voltage change per reading

J55 pin 18 grounded = 1/60 Sec Samples

J55 pin 35 grounded = Low-Sensitivity 1st-Sample

The higher rates require external voltage triggers.

Table 3-3. Maximum Reading Rate

3-20. Maximum reading rate is greater on the high ranges of the DC, Bypass, and Ohms functions because a short 2nd sample is not permitted on the low ranges. Both samples on the high ranges may be programmed to the short, 1/60 sec sample.

3-21. The AC functions have a lower max reading rate than the other functions because a delay period is inserted at the beginning of each reading to allow for the response time of the 3461A AC Converter output filter.

3-22. Programming of 1/60 Sec Samples appreciably increases the max reading rate on the top DC, Bypass, and Ohms ranges by shortening both sample periods for a considerably shorter total reading period. Programming of Low-Sens 1st-Samp, as well as a voltage change between readings, also increases the max reading rate by shortening the 1st sample, assuming that the 1st sample is not already 1/60 sec due to programming of 1/60 Sec Samples. But, the former method is preferred because the latter also causes a change of input sensitivity between samples, resulting in needless relay operation. However, if the input voltage changes between readings, then it is preferable to program Low-Sens 1st-Samp (1/60 Sec Samples may or may not be programmed), rather than allow the 3460B to make the decision to go to low sensitivity for the 1st sample because this avoids a short delay period between readings. The delay is more significant if 1/60 Sec Samples is programmed.

3-23. INPUT CONNECTION.

CAUTION

DAMAGE TO THE 3461A OR 3460B CAN RESULT IF THE FOLLOWING MAXIMUM VOLTAGE LIMITS ARE VIOLATED:

a. MAX VOLTAGE BETWEEN HIGH AND LOW — 1200 VOLTS DC OR RMS.

b. MAX VOLTAGE BETWEEN LOW AND GUARD — 50 VOLTS DC.

c. MAX VOLTAGE BETWEEN GUARD AND INSTRUMENT CHASSIS OR POWER LINE GROUND — 500 VOLTS DC.

3-24. Voltage Measurements (AC and DC).

3-25. The voltage to be measured may be connected to the 3461A VOLTS INPUT Jack, J52, or to the front-panel HIGH and LOW binding posts as selected by the FRONT/REAR Switch. The binding posts accept plain wire leads or leads having banana plugs, and the Rear Input Voltage Cable is left unterminated so that any connector may be fitted.

3-26. In general, the Low terminal should be connected to the lower absolute potential above ground in reference to the High terminal, disregarding polarity.

3-27. If the input voltage is of sufficient magnitude to render common-mode voltages and electrostatic and electromagnetic induced voltages insignificant, then plain insulated copper wire will suffice for input leads and the Guard may be connected to Low. Otherwise, a shielded twisted-pair cable should be used and the Guard connected via the shield to a point of the source circuitry so that

a. Guard is as near as possible to Low potential, with a maximum difference of 50 volts dc; and so that
b. the Guard current does not flow through any source-circuit impedance that is critical to the derivation of the measured voltage.

3-28. Source Resistance. Due to a peculiarity of the 3460B measurement technique, a maximum source resistance of about 100 kΩ must be observed on the 1 V and 10 V ranges of the Bypass function when High-Z is not programmed out.

3-29. Resistance Measurements.

3-30. The resistance to be measured may be connected to the OHMS INPUT Jack, J51, or to the front-panel SENSE and SIGNAL terminals as selected by the FRONT/REAR Switch. For values of resistance that make the input lead resistance insignificant, the High Sense and Signal terminals (red pair of front panel or wires A and D of the Ohms Input Cable) may be shorted together, as well as the Low terminals (black pair of front-panel or wires B and C of the Ohms Input Cable), and only two conductors carried to the unknown resistance. Otherwise, to reject lead-resistance from the measurement, four conductors must be extended to the measured resistance so that the High ones are shorted together at one end of the resistance, and the Low ones shorted together at the other end, providing a four-terminal measurement. All four terminals must be used, whether the connection between Sense and Signal is accomplished at the unknown resistance or the front or rear panel terminals.

3-31. Actually, the resistance of the High Signal lead is not completely eliminated from the measurement unless the rear-panel input jack is utilized and the Lead-Ω Adj, A34R2, calibrated according to the lead resistance. To calibrate R2, simply short together all four rear input leads and adjust R2 for a zero readout. If the front-panel terminals are used, a resistance of about 1.5 Ω in the High Signal lead on the 1 kΩ range will give 1 count (0.01 Ω) on the 3460B.

3-32. As to the use of the Guard in resistance measurements, it should be connected via the shield of the input cable to the end of the unknown resistance where the Low pair of input leads is shorted together.

3-33. CONDENSED OPERATING PROCEDURES.

3-34. AC Measurements.

a. Allow both instruments to warm-up 15 minutes.
b. Select ACN for frequencies below 200 Hz. Select ACF if a reading rate greater than 1/sec (2/sec max) is needed for frequencies above 200 Hz.

c. Select an individual measurement range, or auto-ranging.

d. If ACF was selected for the higher reading rate, program Low-Sens 1st-Samp by grounding wire 35 of the RC Cable.

e. Adjust TRIGGERING RATE or apply external triggers.

f. Select FRONT or REAR input.

g. Connect Guard, Low, and High in that order to avoid surpassing the input voltage limits.

h. Observe readout in rms volts.

i. Disconnect High, Low, and Guard in that order.

3-35. DC Measurements.

a. Allow both instruments to warm-up 15 minutes.

b. Select DC function if the .1 V range is needed, or if continuous high-Z input is desired on the .1 V thru 10 V ranges regardless of input voltage changes. Otherwise, select Bypass function to obviate Preamplifier error. Bypass also has continuous high Z on the 1 V and 10 V ranges if the input voltage changes less than 6% between readings (and high-Z is not programmed out). But even without the continuous high-Z, Bypass has no greater loading error than DC function.

c. Select an individual measurement range, or auto-ranging.

d. Programming

1. Wires 18 and/or 35 of the RC Cable are grounded according to the max reading rate and superimposed noise rejection required, with consideration for the relay activity of the 3460B. For a reading rate greater than 4.5/sec (6.5/sec max) on the .1 V and 1 V ranges, wire 35 of the RC Cable must be grounded, or else the input voltage must change by more than 6% of full scale between readings. Do not indiscriminately ground wire 35, because relay activity then increases. The reading rate requirements for the 10 V thru 1 kV ranges are indicated below:

READINGS/SEC ON 10 V THRU 1 KV AND 10 MΩ RANGES

0 4.5 6.5 14 15.5

Wire 18 or 35 must be grounded, or voltage must change > 6% full scale per reading. Ground wire 35 only if the higher superimposed noise rejection is needed.

Wire 18 must be grounded.

Wire 35 must be grounded if there is > 1% full scale voltage change per reading.

2. If Bypass function was selected, and if a changing input resistance due to a changing input voltage is undesirable, then program out high-Z by grounding wire 22 of the RC Cable.

e. Adjust TRIGGERING RATE or apply external triggers.

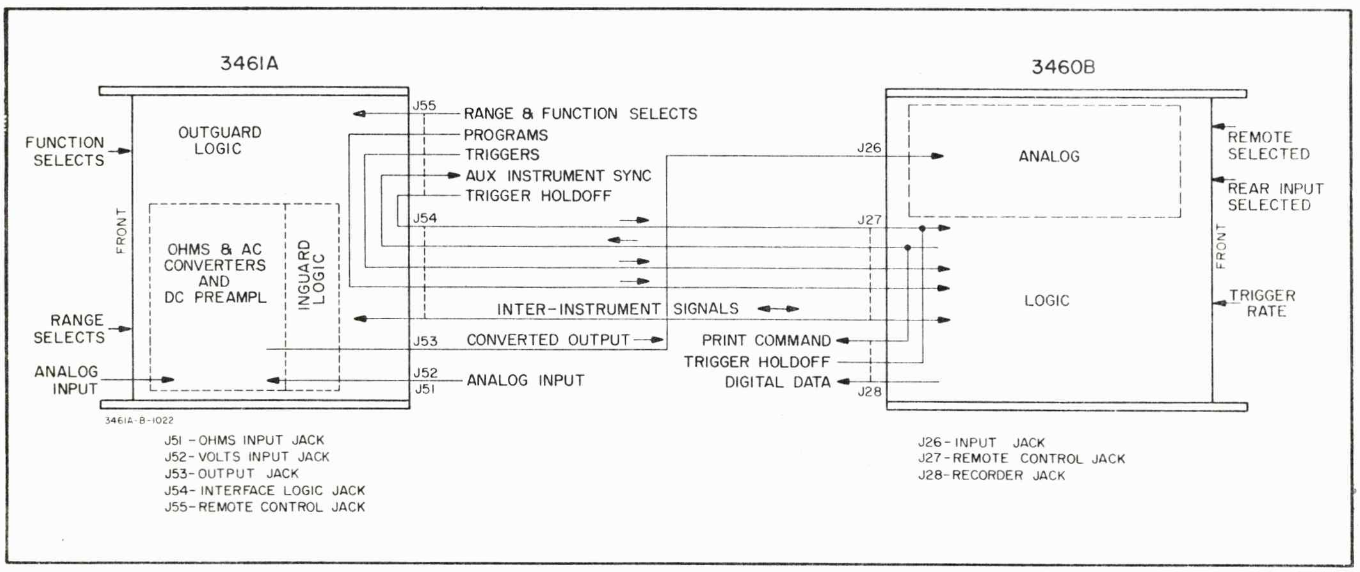
f. Select FRONT or REAR input.

g. Connect Guard, Low, and High in that order to avoid surpassing the input voltage limits.

h. Observe readout in dc volts of either polarity.
i. Disconnect High, Low, and Guard in that order.

3-36. Ohms Measurements.

a. Allow both instruments to warm-up 15 minutes.
b. Select Ohms function.
c. Select an individual measurement range, or auto-ranging
d. If a reading rate greater than 4.5/sec (6.5/sec max) is required on the 1 kΩ thru 1 MΩ ranges, then ground wire 35 of the RC Cable. If a reading rate greater than 4.5/sec (15.5/sec max) is required on the 10 MΩ range, then refer to the graph of Paragraph 3-35d1 which also applies here.
e. Adjust TRIGGERING RATE or apply external triggers.
f. Select FRONT or REAR input.
g. Connect Guard, Low Sense and Signal, and High Sense and Signal.
h. Observe readout in kilohms or megohms.



3461A - 3460B Interconnection Scheme

SECTION IV

THEORY OF OPERATION

4-1. First to be discussed are the analog circuits of the AC and Ohms Converter and DC Preamplifier, followed by the logic circuitry responsible for selection of instrument range and function.

4-2. AC CONVERTER. (Figures 7-2, 7-3)

4-3. The AC Converter consists of two series connected amplifiers, each with an attenuator, and a half-wave rectifier and low-pass filter. Relays K1 and K15, and K5 and K16 couple the ac voltage into the Converter, and the dc converted voltage out to the 3460B. K2 and K3 switch the gain of each amplifier for ranging, and K4 adds additional filtering for frequencies below 200 Hz. In the ac-only instrument (Option 02) a Jumper Assembly subsititutes for K15 and K16, and the DC/Ohms Relay Assembly A35 is not installed.

4-4. Ranging is achieved by switching the gain of the AC Converter while holding the 3460B on the 1 V measurement range, but properly enunciating the readout range. Buffer Amplifier gain factors of 1/200 and 1/2 are paired with ac-to-dc conversion ratios of 2/10 and 2 obtained from the Final Amplifier, Half-Wave Rectifier, and Low-Pass Filter. Four aggregate ac-to-dc gain factors result: 1/2 x 2 = 1, 1/2 x 2/10 = 1/10, 1/200 x 2 = 1/100, and 1/200 x 2/10 = 1/1000. Two values of feedback resistance, R_F, vary the Buffer gain: $A = R_F/R_S$ = either 25 kΩ/5 MΩ or 2.5 MΩ/5 MΩ = either 1/200 or 1/2. Whereas, the Final ac gain is varied by the series resistance, R_S: $A = (R_F/R_S)(1 + R_M/R_N)$ = either (2.5 kΩ/50 kΩ) (1 + 900 Ω/100 Ω) or (2.5 kΩ/5 kΩ) (1 + 900 Ω/100 Ω) = either 1/2 or 5.

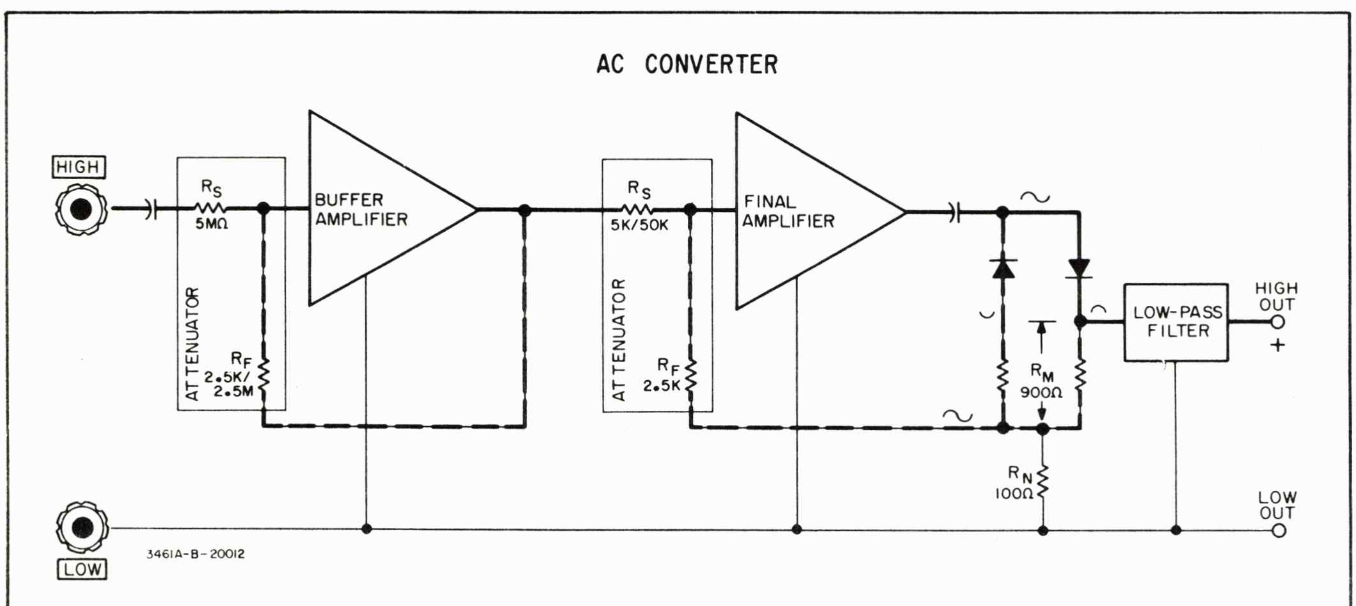


Figure 4-1. AC Converter

4-5. Both amplifiers have a gain accuracy of $\pm 0.25\%$ for the 50 Hz to 100 kHz spectrum; but the product of the two is assured by the two attenuators to be within the specified accuracy of the Converter.

4-6. Buffer Amplifier.

4-7. The Buffer Amplifier is an operational amplifier of -10^4 open loop gain. Transistors Q1 through Q3 are a differential stage between the input voltage and feedback from Q4, with an output from Q2 immune to power supply fluctuations. Q9 provides a bias current for this stage, that is adjusted by rotating R16 to the zero-output balance point of the Differential Amplifier. Q6 through Q8 provide a low impedance output to the Final Amplifier.

4-8. Saturation of the amplifier is prevented by a protective feedback loop, CR1 through CR10, that limits the output voltage to about 9 volts peak. Three diode stages in the loop reduce transfer capacitance during normal non-overload condition.

4-9. Final Amplifier.

A voltage-to-current gain by the Final Amplifier generates a half-wave voltage across R35 that is independent of rectifier CR13 voltage. This half-wave is applied to the low-pass filter and also summed across R36 with the other half-wave through CR12. The reconstructed wave is fed back to the input for gain attenuation. Q1 through Q3 are a differential amplifier of the input voltage and feedback voltages from Q5 and Q11. Feedback for bias stability is provided by Q10 and Q11 which are connected in a differential manner to reject power supply fluctuations. An overload loop is provided as in the Buffer Amplifier, except that the output voltage at TP1 is here limited to about 5 volts peak. CR10 and CR11 are added protection against sharply rising input voltages until the overload loop can act.

4-10. DC PREAMPLIFIER. (Figures 7-2, 7-4)

4-11. A chopper-stabilized Preamplifier of X10 gain operates in conjunction with the 3460B 1 V measurement range to create a .1 V range having greater than 10^{10} ohms input resistance. It also operates with the 1 V and 10 V ranges of the 3460B, but with unity gain, to achieve the same high input resistance. K7, K8, K14, K15, and K16 are the input and output relays of the Preamplifier. K6, K15, and K16 bypass the Preamplifier on the 100 V and 1 kV ranges of the DC function and on the four ranges of the Bypass function.

4-12. The high accuracy of the Preamplifier is accredited to the use of a high gain amplifier ($A = -10^8$) as a super emitter-follower. The Gain Network serves as the load across which the Preamplifier input voltage from High to Low is essentially reproduced, with negligible voltage across the high-gain input from High to ⏚. E_{IN} is reproduced between ⏚ and Low input to oppose E_{IN} so that the high-gain input is held at $E_{IN}/10^8$, and E_{IN} (or E_{IN} x 10) appears between ⏚ and ▽. An X10 Preamplifier gain is achieved by simply moving the Low input up to a 10-to-1

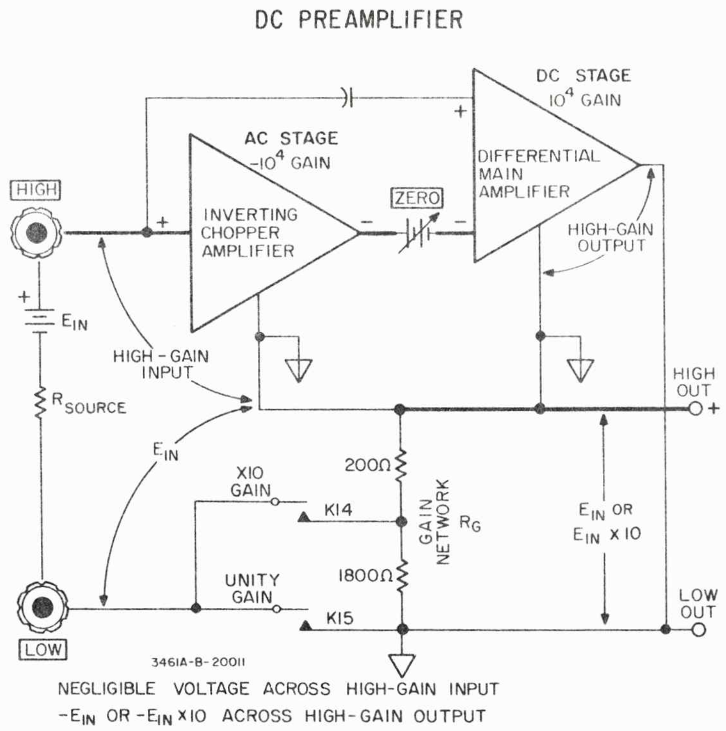


Figure 4-2. DC Preamplifier

tap on the Gain Network so that the high gain amplifier must impress E_{IN} x 10 across the total Gain Network to provide the necessary E_{IN} between ⏚ and Low input. The opposition of E_{IN} by the voltage of the Gain Network results in the high input resistance; and the ability of the high gain amplifier to hold the Gain Network voltage equal to E_{IN} irrespective of the output current results in the low output resistance of less than 1 Ω.

4-13. The Preamplifier achieves dc stabilization by utilizing first an ac stage, and then overall dc feedback following the dc second stage to degenerate the effect of drift voltages in the dc stage. Any drift voltage in the dc stage can be represented by a battery at the input of the stage as shown in Figure 4-2. The Preamplifier output error voltage due to the battery is the battery voltage divided by the 10^4 gain of the Chopper Amplifier. Thus if the battery is 1 mV, the output error voltage is only 0.1 μV. A Preamplifier ZERO adjustment is provided by a voltage source at this same input to the Main Amplifier. Its output effect is likewise divided by the Chopper Amplifier gain.

4-14. To permit ac amplification, photoconductors are employed to create a 220 Hz waveform from the input voltage of the high gain amplifier, and then to synchronously rectify the signal after amplification. A low-pass filter C7, R26, C8 and C9 completes the conversion back to dc. Chopping is accomplished by alternating the resitance of photoconductors V1 and V2 with pulses of light from DS1 and DS2. The illuminated resistance is a few kilohms, and the "dark" resistance several megohms. Rectification is accomplished by V3 and V4. A polarity reversal exists between HIGH input and TP3.

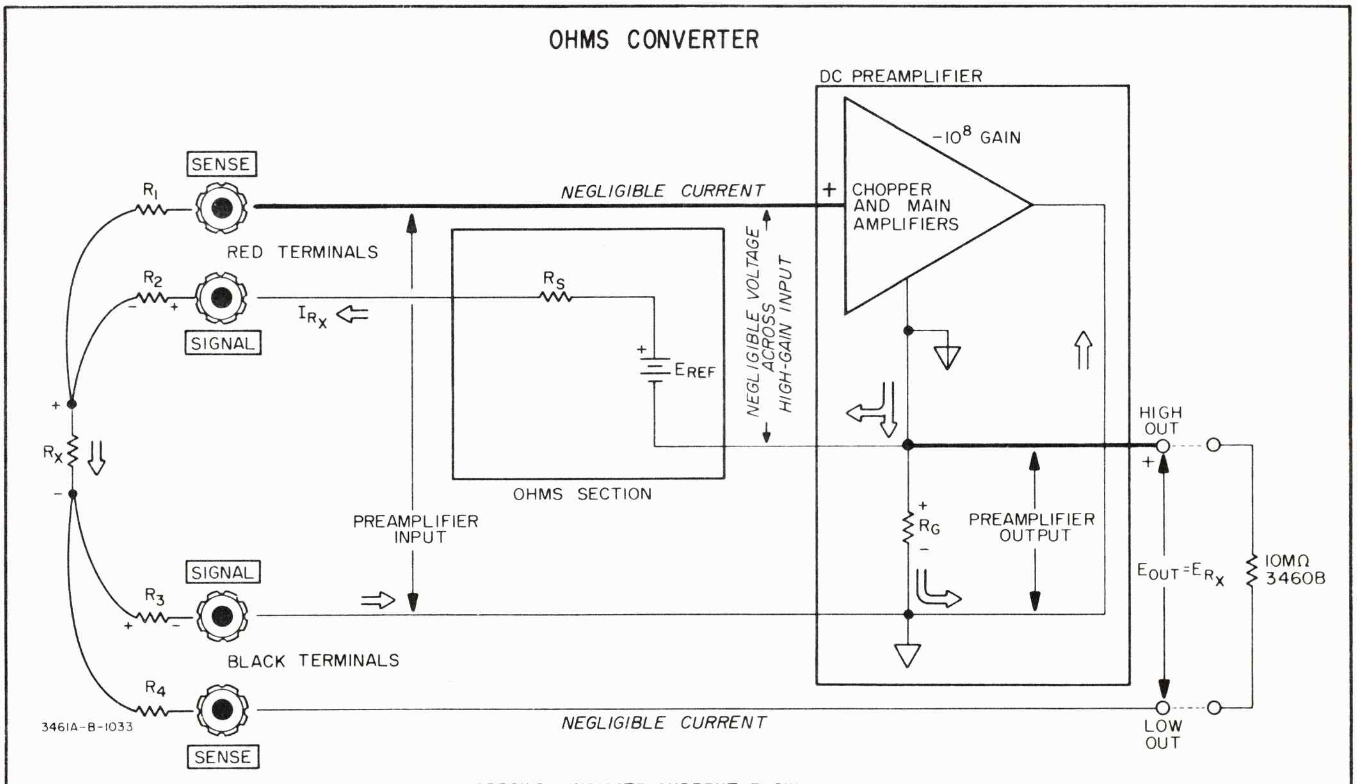
4-15. A 1 MHz bandwidth of the Preamplifier assures good response to input voltage changes. Frequency components above about 40 Hz bypass the Chopper Amplifier through C10 to the Differential Amplifier. The output of the Differential Amplifier is proportional to the voltage difference between TP3 and TP4. The Output Amplifier provides a low impedance output to the Gain Network.

4-16. BYPASS CONFIGURATION. (Figure 7-2)

Relays K6, K15, and K16 provide a direct path from the 3461A High and Low input terminals to the 3460B input, bypassing the DC Preamplifier. This configuration allows the four 3460B ranges to be used directly on Bypass function; and also allows the 100 V and 1 kV ranges of the 3460B to be selected on DC function to accompany the three Preamplifier ranges.

4-16. OHMS CONVERTER. (Figures 7-2, 7-4)

4-17. In the Ohms function, the unity-gain DC Preamplifier, a Reference Voltage Supply, and a Ranging Network constitute a constant-current, four-terminal, resistance-to-voltage converter. A linear conversion is achieved by the constant-



ARROWS INDICATE CURRENT FLOW

RANGE	R_S	E_{REF}	I_{Rx}
1KΩ	13.96KΩ	13.96V	1MA
10KΩ	139.6KΩ	13.96V	100μA
100KΩ	1.396MΩ	13.96V	10μA
1MΩ	5MΩ	5V*	1μA
10MΩ	5MΩ	5V*	1μA

*EFFECTIVE

Figure 4-3. Ohms Converter

current method, and a tolerance to input lead resistance is realized by the four-terminal arrangement.

4-19. A constant-current through the measured resistance irrespective of the value of the resistance (for a particular range) is achieved by using the DC Preamplifier to "bootstrap" the reference voltage. Assume for the moment that the lead resistances are zero; then the Preamplifier action holds E_{RG} very nearly equal to E_{RX}. With a near zero voltage maintained across the Ohms Section, I_{RS} must equal E_{REF}/R_S. But I_{RS} equals I_{RX} because no current flows through R_1 and R_4 due to the high input impedance of the Preamplifier and the 3460B. Therefore, the current through R_X is dependent only upon R_S and E_{REF}; and the Preamplifier output voltage is directly proportional to the measured resistance.

4-20. To alleviate R_3 as a source of error, since its voltage is actually summed with E_{RX} to appear across R_G, the Converter low-output is sensed through R_4. Now, E_{R3} is subtracted out of the measurement, since $E_{OUT} = E_{RG} - E_{R3} = (E_{RX} + E_{R3}) - E_{R3} = E_{RX}$. As mentioned before, no current flows through R_1 and R_4, so they contribute no error.

4-21. Since lead resistance R_2 is in series with R_S, it affects I_{RX} to the extent of R_2/R_S x 100 percent, which is maximum on the 1 kΩ range where R_S has a minimum resistance of 13.96 kΩ. To compensate for this source of error, a 9 Ω resistor, A34R1, is placed in series with R_S through the front panel; and a 10 Ω variable resistor, A34R2 Lead-Ω Adj, in series with R_S through the rear panel. Each range is then calibrated through the front panel terminals with the 9 Ω added to R_S so that when the rear panel input is used the Lead-Ω Adj allows compensation for the lead resistance.

4-22. Ranging is accomplished among the 1 kΩ through 100 kΩ ranges by holding the 3460B on the 1 V range and changing R_S by multiples of 10 to give different currents through R_X of 1 mA, 100 μA, and 10 μA respectively. For the 1 MΩ and 10 MΩ ranges, the current is reduced to 1 μA by changing R_S to 5 MΩ and adding a shunt around E_{REF} and the R_S of the 100 kΩ range so that the effective reference voltage is 5 volts. The 10 MΩ range is achieved by selecting the 3460B 10 V range.

4-23. GENERAL LOGIC.

4-24. Gates, multivibrators, drivers, and delay capacitors implement the logic functions and electrical conditions required to manipulate the seventeen range and function relays of the 3461A, and to select the readout range and actual measurement range and also reading delays of the 3460B. Individual selection of 3461A range and function is from the 3461A front-panel pushbuttons or Remote Control Jack. Auto-ranging is accomplished by commands from the 3460B. The 3460B never selects its own range, even when generating auto-ranging commands to the 3461A.

4-25. Logic Signals.

4-26. Each logic signal is exhibited throughout the circuitry as two distinct electrical states or levels referred to as "true" and "false" or "1" and "0." All signals of the 3461A have a low voltage of either polarity or else a short to circuit common as the "1" level; and a high voltage usually greater than 10 volts of either polarity or else an open circuit as the "0" level. * Some lines carry the inverse of a signal (inverted electrical levels), and the signal name is overscored to denote this. Thus, if signal M is "true" (instrument on an AC function), then $\overline{M}$, referred to as "not-M," is at the "false" electrical level. Conversely, if the $\overline{M}$ line is at ground potential ("true"), then M is "false" (instrument not on AC).

4-27. Active Logic Level. Each signal has one electrical level as intrinsically true by definition, whether it originates from a switch, jack, gate, driver, or multivibrator. However, the false level in many instances is the one that affords the "active" input to a gate or driver. This is indicated by a logic inverter, a small circle at the input of a gate or driver symbol. The logic inverter of driver 3 indicates that K21 is energized to give a "low" through the Guard only when $\overline{M}$ is false (M true). It is apparent then, that logic inverters cancel inversion bars above signal names.

4-28. AC Coupling. In some instances, signals are capacitively coupled to circuits and so are active only at the instant they alternate logic levels ("0" - to - "1" in all cases).

4-29. Gates.

4-30. There are two varieties of gates as defined:

OR gate - a circuit whose output signal is true when any input signal is active; and false when all input signals are not active. (See Paragraph 4-27.)

AND gate - a circuit whose output signal is true when all input signals are active; and false when any input signal is not active.

4-31. Virtual Gates. In the Range Selector and "NO" Driver circuits, signal lines are directly connected together to form the effective OR gate 51 and part of gate 2.

4-32. Gate Equations. Multiple gate functions can be concisely stated by Boolean Algebra equations, where a dot indicates the AND function and a plus sign the OR function. A logic inverter is represented in the equation by a bar above the signal

* The Trigger lines and Trigger Holdoff line are true at the "high" electrical level, but are not considered part of the 3460B circuitry since they run directly from the RC Jack to the 3460B.

name; although, for an inverted signal, it is logically equivalent to just delete the inverter bar present as to add another. This logic prerogative is exemplified by the following equation of the Downrange Inhibit signal:

$$\text{Dr Inhb} = \left\{\left[(M + BY) \cdot K \cdot L\right] + J\right\} \cdot \text{ 60 Rem},$$

which displays K and L rather than $\overline{\overline{K}}$ and $\overline{\overline{L}}$ as would be written strictly from the symbols of the Logic Block Diagram. The equation reads that Downrange Inhibit is true or occurs when M or BY along with K, L and 60 Rem are true; or else when J and 60 Rem are true.

4-33. Multivibrators.

4-34. Bistable. Each bistable multivibrator (flip-flop) has two mutually inverted outputs, with both combinations of output levels as stable states. The name of the "clear" output line (output opposite C input) is overscored with a bar to denote that it is logically inverted from the "set" output under normal operating conditions. A change of state (alternation) is accomplished by the input signals. Consider the J flip-flop; its true state (J true) is selected by a "set" input, and its false state (J false) by a "clear" input. The K and L flip-flops also have a "toggle" input, which is to alternate the flip-flop, whichever its state, if both "set" and "clear" inputs are false. A possible "non-logical" state of the flip-flops is employed in the case of J to illuminate the "NO" Indicator. Both output lines are at the false voltage level if both S and C inputs are abnormally held true. This non-logical condition cannot exist on lines inside the Guard.

4-35. One-Shot. This single-output multivibrator has only the false state as stable, and has only one "trigger" input operation. A true output prevails for only about 7 milliseconds following a "0" - to - "1" input alternation.

4-36. Drivers.

Drivers have logical significance only if they provide inversion, as indicated by the usual logic inverter symbol; otherwise they provide only the normal power amplification.

4-37. Delay Circuits.

Capacitors are used in some gates to delay the occurrence of the true output. The false output is not delayed.

4-38. RANGE AND FUNCTION SWITCHES. (Figures 7-5, 7-6)

The simplified presentation of the Range and Function Switches on the Logic Block Diagram is for convenience in showing that the front-panel pushbuttons either ground inputs to the counters or else allow remote grounding of these inputs. Certain minor peculiarities of the switches may be identified by scrutinizing the actual schematic of the switch, Figure 7-6.

4-39. RANGE AND FUNCTION COUNTERS. (Figures 7-5, 7-6)

4-40. Expression of instrument range and function, except Bypass function,* by the storage of counters J - K - L and M - N allows remote selection of range and function by a momentary ground at the RC Cable as well as by a continuous ground.

4-41. Gates 8 thru 13 operate to give a different output logic-level combination from the J, K, and L flip-flops for each range selected. A peculiar "non-logical" state of the J flip-flop is instigated by gates 8 and 9 if the .1 V range on ACN, ACF, or Bypass is selected. Signal A into gate 8 is true on the .1 V range, and M into gate 9 is true on either AC function. With both of these inputs true, the flip-flop assumes a state such that both J and $\overline{J}$ lines are at the high voltage level. This condition illuminates the "NO" lamp via gate 1 on A4.

4-42. In AUTO RANGE mode, gates 3 thru 9 toggle the K and L flip-flops and "set" or "clear" the J flip-flop according to the Uprange and Downrange Commands that arrive from the 3460B via the Auto Inhibit. The process follows: A "0" - to - "1" alternation of DR "sets" J true if K and L at gates 3 and 5 are true, alternates the K flip-flop if L at gate 3 is true, and alternates L - $\overline{L}$ each time. UR alternating from "0" - to - "1" "clears" J if J is not already false, alternates K - $\overline{K}$ if $\overline{L}$ at gate 4 is true, and alternates the L flip-flop each time.

4-43. Gates 14 thru 17 produce different M - N combinations for each function except Bypass. Notice that gates 15 and 17 select ($\overline{M} \cdot \overline{N}$) as true for both DC and Bypass.

4-44. "NO" DRIVER. (Figures 7-5, 7-6)

In Option instruments, jumpers on A4 are connected so that the 3461A function-select signal of each function not installed in the instrument is conveyed to the "NO" Driver rather than to the Function Counter. Gate 2 also illuminates the "NO" lamp if the .1 V range is selected on ACN, ACF, or Bypass function. This improper selection gives two "high" logic levels to gate 1 from a "non-logical" state of the J flip-flop.

4-45. AUTO BUFFER. (Figures 7-5, 7-6)

To preclude the possibility of having the Auto Range Select signal choose the auto-range mode of the 3460B while the 3460B is being used alone but still interconnected to the 3461A, gate 55 assures that ARS cannot become true unless REMOTE RANGE of the 3460B is selected.

4-46. AUTO INHIBIT. (Figures 7-5, 7-7)

4-47. Auto-ranging of the 3461A-3460B system is accomplished by having the 3460B range the 3461A Range Counter, and then having the 3461A select the proper

* See Paragraph 4-54.

readout range and actual measurement range of 3460B. The Auto Inhibit prevents the generation of the 3460B auto-ranging commands when the 3461A is already on the highest or lowest range.

4-48. Uprange Inhibit Section.

4-49. Uprange Command is active at driver 9 to affect the Range Counter only when it alternates from "high" electrical level to "low." This transient from "0" - to - "1" is prevented from occurring by gate 42 when J, K, and L are false (1000 V or 10 MΩ range). Gate 42 is tied to the Uprange Command line via gate 43 so that when its output becomes "low" (UR Inhibit true), the Uprange Command line cannot go "high" and then back to "low" to become active. Gate 43 gates-in 60 Remote from the 3460B so that gate 42 can hold the Uprange Command line "low" only when REMOTE RANGE of the 3460B is selected.

4-50. When the 3461A is on the 10 MΩ or 1 KV AC range on AUTO, the 3460B must know this in order for it to terminate readings when overloaded. Since UR Inhibit has the required characteristic, being true on the top range and false otherwise, it is simply renamed High Range and fed to the 3460B on a separate line.

4-51. Downrange Inhibit Section.

Downrange Command is prevented from occurring by gates 44 thru 46 when J is true (.1 V DC or 1 kΩ range), or when K and L and either M or BY are true (1 V AC or BY range). 60 Remote is also gated-in as in the Uprange Inhibit Section.

4-52. RANGE SELECT. (Figures 7-5, 7-7)

Gates 42 and 48 thru 54 select the measurement range of the 3460B according to the needs of the AC Converter, DC Preamplifier, and Ohms Converter. (The readout range of the 3460B is selected by the Outguard Driver.) Notice from Table 4-1 that the 3460B 1 V range is used most. This preferred range is selected when the 10 V, 100 V, and 1 kV Range Selects are false, giving three active inputs to gate 54. The 10 V range is selected by gates 42 and 48 thru 51 when $\overline{J} \cdot \overline{K} \cdot \overline{L} \cdot \overline{M} \cdot \overline{N}$ = "1," or when $K \cdot \overline{L} \cdot \overline{M} \cdot \overline{N}$ = "1." Gates 49 and 50 are in parallel to provide gate 51. Selection of the 100 V range is by gates 48 and 52 when K and M and N are false, and L true. When J, K, L, M, and N are all false, gates 42, 48, and 53 select the 1 kV range.

4-53. OUTGUARD DRIVER. (Figures 7-5, 7-8)

4-54. The Outguard Driver supplies the range and function data of the Counters (the "set" output of each flip-flop) to the inguard logic of the 3461A via K18 thru K22, and to the Converter Adapter of the 3460B via J54, but as stipulated: J - thru - N affect the 3460B only when the 3460B is on REMOTE RANGE, as necessary for the 3461A to control the 3460B; and the inguard counterpart of K, denoted by ~~K~~, is restricted from becoming true on Bypass function by gate 19. ~~K~~ signal is created in order to define the fifth function, Bypass, in addition to those functions storable in the Function Counter. A consequence of this technique to distinguish the Bypass

function from the others is that the Bypass Select line must be held at ground, as opposed to those for ACN, ACF, DC and Ohms.

4-55. Gate 18 is a safety circuit to protect the DC Preamplifier, should J stick at the "1" level. It imparts no additional logical significance to the J it passes; it just insures that J in-guard can never become true on the Bypass configuration, as normal. (Bypass configuration is utilized on Bypass function and top two ranges DC function.) With J true when Bypass relay K6 is energized; K7, K8, and K14 would be closed, allowing any high instrument input voltage to be directed to the input and output of the high gain amplifier. Also with this abnormal condition, K14 rather than K15 would be closed on ACN, placing part of the Gain Network in the Low line.

4-56. AC/BYPASS DRIVER. (Figures 7-5, 7-8)

The AC/Bypass Driver interprets the range and function data of the Counters to operate the AC and Bypass relays K1 thru K6; to derive inverted J, ~~K~~ and N signals as needed by the DC/Ohms Driver; and to generate a Change-of-State signal to protect the Preamplifier, the AC filter, and various relays. Gate 41 monitors each range and function change that switches in or out the Preamplifier or changes the Preamplifier gain. The COS one-shot is triggered each time to hold High Relays K5 thru K9 open, and Low Relays K15 and K16 closed for 7 msec prior to the final relay selection. This prevents a high instrument input voltage from damaging the circuits during ranging. Delay capacitors C1 and C2 of this assembly, and C1 thru C3 of A23 provide further assurance that K5 and K6; or K7, K8, and K6; or K7 and K8 are never simultaneously closed.

4-57. DC/OHMS DRIVER. (Figures 7-5, 7-8)

The DC/Ohms Driver is responsible for the operation of Low Relays K14 thru K17, DC Relays K7 and K8, and Ohms Relays K9 thru K13. As an example of the logic involved, consider gates 35 and 36 which operate K14 and K15. K14 is energized when J is true and N false; K15 is energized when K14 is not energized, or while COS occurs. Capacitors C1, C2 and C3 delay the closing of K7 thru K9 as mentioned in the preceding paragraph.

4-58. POWER SUPPLIES. (Figures 7-9, 7-10)

4-59. There are four power supplies in addition to the Ohms Reference Supply. Each of the power supplies use one or two separate windings of the power transformer and operate the same. The Series Regulator of each power supply is biased by the Amplifier transistor so as to oppose any output voltage variations that tend to appear across the two-resistor voltage divider at the base of the Amplifier (R13 and R14 of the Outguard Logic Power Supply). If the output voltage increases, the Amplifier conducts harder, absorbing more of the current of the Current Source in proportion to that drawn by the Series Regulator, increasing the Series Regulator collector resistance and opposing the rising output voltage trend. Should the output voltage decrease, the Amplifier reduces conduction to lower the Series Regulator collector resistance and again oppose the output voltage change.

4-60. A Current Limit is provided for protection against excessive demands on the Power Supply. The transistor is biased off until enough current is drawn through the Series Regulator emitter-series-resistor (R12 of the Outguard Logic Power Supply) to bias it into conduction. It then acts as the Sensor Amplifier does when the output voltage rises, to sump bias current away from the Series Regulator. But since this lowers the power supply output voltage, the current must now begin to decrease; and as a result of the reduced voltage, less current is now required to hold the Current Limit conducting; so the voltage and current both continue to decrease as the power supply load resistance is reduced to zero. However, THE CURRENT LIMITS DO NOT NECESSARILY AFFORD PROTECTION AGAINST A SHORT BETWEEN THE + 25 V AND - 25 V OUTPUTS, NOR DO THEY PROTECT AGAINST "INTERNAL" SHORTS.

4-61. OHMS REFERENCE SUPPLY. (Figure 7-11)

The Ohms Reference Supply operates from the Preamplifier Power Supply output rather than from a winding of the Power Transformer. A Darlington circuit Regulator is driven from Q2 of a Differential Amplifier which senses output voltage variations at Q1B in reference to CR1 voltage. Resistors R17 thru R21 are shorted-out according to Table 5-3 to accommodate variations among Reference diodes. The Reference Supply voltage is adjusted as a calibration for the 1 kΩ range by rotating A34R24 to change the bias at Q1B base. An oven temperature of 68 $\pm 2^{\circ}$C is maintained by a thermostatically controlled heater HR1.

4-62. NEON CONTROL. (Figure 7-9)

A 220 Hz astable multivibrator, A43Q9 - Q10, alternately pulses DS1 and DS2 of the DC Preamplifier by completing the "ground path" to the Neon Supply. To insure that both neons are never simultaneously illuminated, Q11 cuts off both neons each time the Neon Oscillator alternates.

4-63. GUARDING.

4-64. Common-Mode Rejection.

4-65. Common-mode voltages if not properly handled can cause appreciable errors in floating voltage measurements (Low is not equal to ground potential), if the source and instrument are line operated. Figure 4-4 illustrates pertinent instrument impedances and a model of the source involved in unguarded dc voltage measurements. The source model is a three-terminal generalization of the two-terminal Thevenin-equivalent circuit, where E_x is the voltage to be measured, E_s is ac noise frequently found superimposed upon (in series with) the dc to be measured, and E_{CM1}, E_{CM2} are the dc and ac common-mode voltages developed between Low and instrument ground by the source and extraneous causes. (Since High is taken to be the terminal of the source that is at the higher absolute potential above ground, E_x and E_{CM1} are oriented the other way in "negative" measurements.) Z_2 is parallel resistance and capacitance leakage paths from the Low input terminal to chassis, and contains the inter-winding capacitance of the power

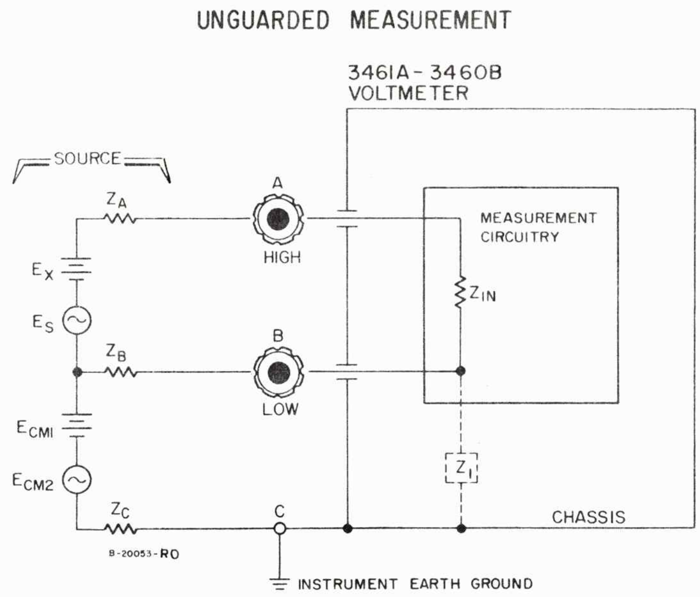


Figure 4-4. Outguarded DC Measurement

transformer. This "three-terminal" setup allows common-mode voltages to generate error voltages and superimposed noise across Z_B via Z_1.

4-66. An improved arrangement using an internal Guard to reject common-mode errors is shown in Figure 4-5, where Z_2 is the leakage between Guard and instrument chassis. With the Guard connected as shown, to the node of the source model, the instrument and source together are "bootstrapped" by E_{CM1} and E_{CM2}, such that common-mode currents flow only through Z_2 in this "four-terminal" scheme. Common-mode voltages now displace both High and Low from ground, but do not move them apart with a voltage across Z_B.

4-67. Since the actual source circuit will not usually have the form of the model, some general criteria for Guard connection are necessary. Upon examination of the model, it can be seen that

a. Guard is driven from the same common-mode potential as Low, and
b. the Guard current does not flow through Z_B.

4-68. As an example of the optimum Guard connection to an actual circuit, consider the circuit of Figure 4-6, shown with its model. Since the node of the model does not physically exist in this circuit, it becomes necessary to fabricate a point having the required characteristics for Guard connection. Two resistors, R4 and R5, are added to the circuit so that their junction, where Guard is to be connected, is at the same potential as Low; and so that the Guard current through these does not pass through R1, R2 or R3 from which Z_B of the model is derived.

4-69. THE GUARD MUST BE CONNECTED WITHIN 50 V OF LOW. If a proper drive point is not available, then connect Guard directly to Low. With the Guard

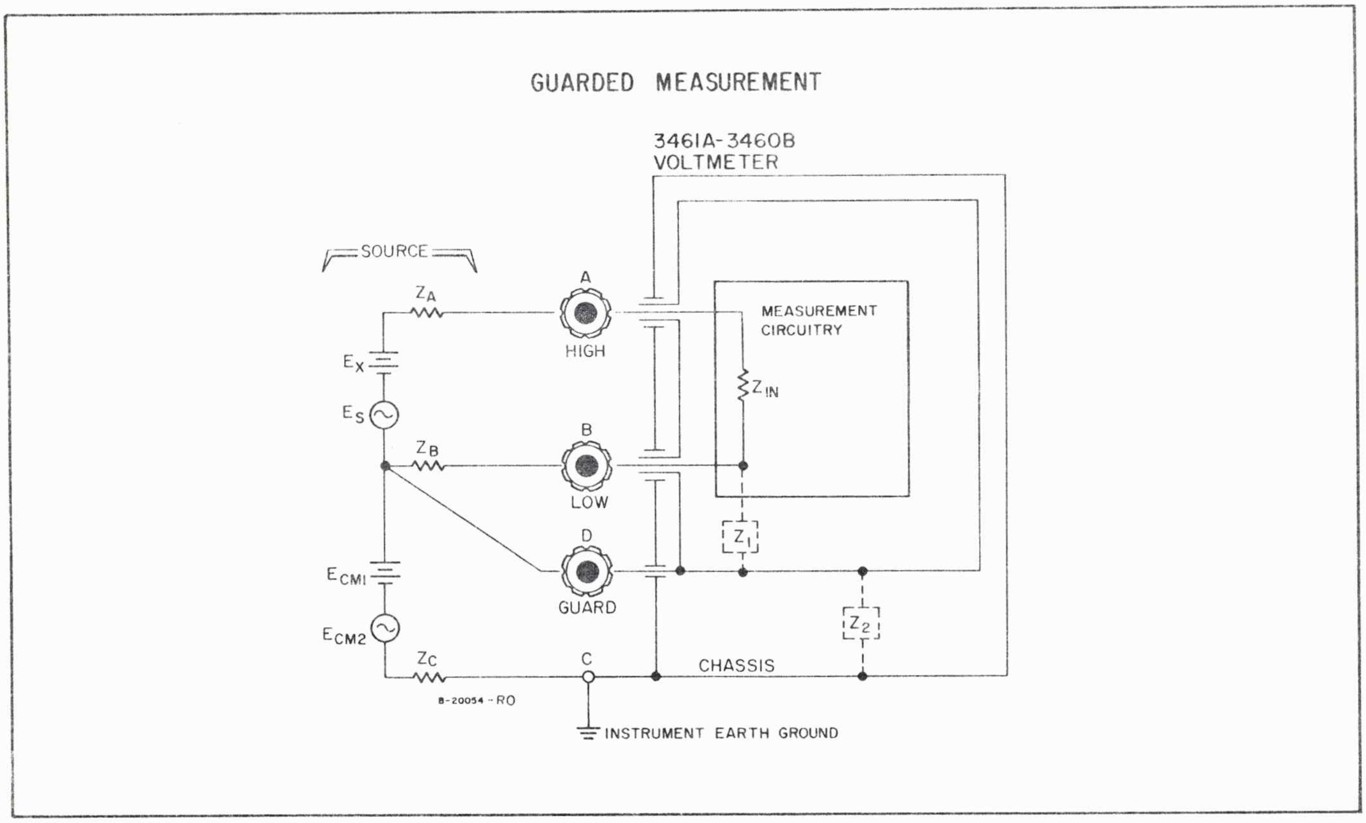


Figure 4-5. Guarded DC Measurement

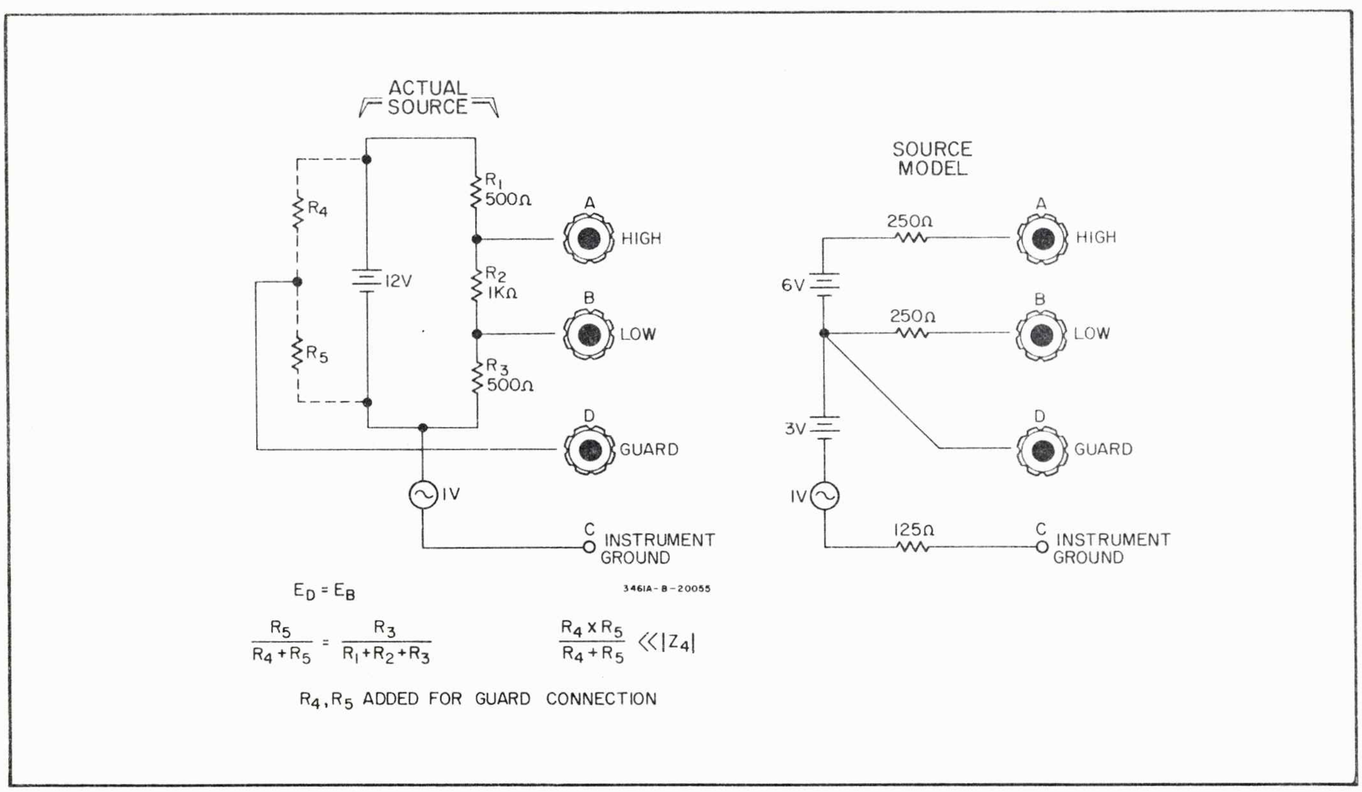


Figure 4-6. Guard Hookup

connected to Low, Z_2 becomes the major contender for common-mode leakage, but is less significant than the Z_1 of the unguarded instrument because it does not contain the capacitance of the power transformer.

4-70. For ac voltage measurements the same rules apply when connecting Guard; although, the source model is changed to that of Figure 4-7. The dc common-mode voltage is ignored, but E_{CM2} is a possible source of harmonic error unless rejected by guarding.

4-71. The ability of the voltmeter to reject common-mode voltages, as measured in decibels, is stated by the following equations, where E_o is the voltmeter response: DC common-mode rejection = 20 $\log_{10}(E_{CM1}/E_o)$, assuming that $E_x = E_s = E_{CM2} = 0$, but $E_{CM1} \neq 0$. AC common-mode rejection = 20 $\log_{10}(E_{CM2}/E_o)$, assuming that $E_x = E_s = E_{CM1} = 0$, but $E_{CM2} \neq 0$.

4-72. Superimposed Noise Rejection.

Superimposed ac voltages in dc measurements can shift the scale factor and/or the zero by consuming the dynamic range of the instrument. In ac measurements it prevails as direct harmonic error. It cannot be rejected by the guarding technique, but is rejected by an integrating technique within the 3460B, and also by an input filter in the Model 3460BF.

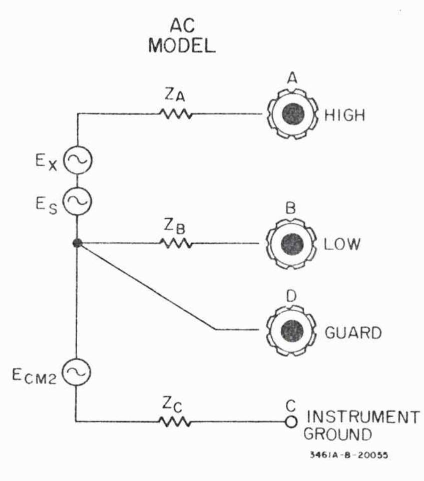


Figure 4-6. AC Source Model

Table 4-1. Range and Function Relays

FUNCTION & RANGE		FLIP-FLOP STATES					ENERGIZED RELAYS																						3460B MEASUREMENT RANGE
		RANGE			FUN		AC					BY	DC		OHMS					LOW				THROUGH-GUARD					
		J	K	L	M	N	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K15	K16	K17	K18	K19	K20	K21	K22	
ACF	1 V	0	1	1	1	1	X		X		X										X	X			X	X	X	X	1 V
	10 V	0	1	0	1	1	X				X										X	X			X		X	X	1 V
	100 V	0	0	1	1	1	X	X	X		X										X	X				X	X	X	1 V
	1 kV	0	0	0	1	1	X	X			X										X	X					X	X	1 V
ACN	1 V	0	1	1	1	0	X		X	X	X										X	X			X	X	X		1 V
	10 V	0	1	0	1	0	X			X	X										X	X			X		X		1 V
	100 V	0	0	1	1	0	X	X	X	X	X										X	X				X	X		1 V
	1 V	0	0	0	1	0	X	X		X	X										X	X					X		1 V
OHMS	1 kΩ	1	0	0	0	1		x						X	X	X					X		X	X				X	1 V
	10 kΩ	0	1	1	0	1			x					X	X		X				X		X		X	X		X	1 V
	100 kΩ	0	1	0	0	1								X	X			X			X		X		X			X	1 V
	1 MΩ	0	0	1	0	1		x	x					X	X				X		X		X			X		X	1 V
	10 MΩ	0	0	0	0	1		x						X	X				X		X		X					X	10 V
DC	.1 V	1	0	0	0	0		x		x			X	X						X		X		X					1 V
	1 V	0	1	1	0	0			x	x			X	X							X	X			X	X			1 V
	10 V	0	1	0	0	0				x			X	X							X	X			X				10 V
	100 V	0	0	1	0	0		x	x	x		X							x		X	X				X			100 V
	1 V	0	0	0	0	0		x		x		X							x		X	X							1000 V
BY	1 V	0	1*	1	0	0		x	x	x		X							x		X	X				X			1 V
	10 V	0	1*	0	0	0		x		x		X							x		X	X							10 V
	100 V	0	0	1	0	0		x	x	x		X							x		X	X				X			100 V
	1 kV	0	0	0	0	0		x		x		X							x		X	X							1000 V

* K inguard, denoted by ~~K~~, never becomes "1" on Bypass function.

Small x's denote relays that are energized but not pertinent to the range.

NAME			LOCATION	EQUATION
K1	AC	AC Input	Chassis A50	$K1 = K21 = M$
K2		100 V/1 KV AC	AC Attenuator Assy	$K2 = \overline{K19} = \overline{K} + BY = \overline{K}$
K3		1 V/100 V AC	AC Attenuator Assy	$K3 = K20 = L$
K4		AC Normal	AC Filter Assy	$K4 = \overline{K22} = \overline{N}$
K5		AC Output	AC Filter Assy	$K5 = M \cdot \overline{COS}$
K6	BY	Bypass	Chassis A50	$K6 = \overline{J} \cdot \overline{\cancel{K}} \cdot \overline{M} \cdot \overline{N} \cdot \overline{COS}$
K7	DC	DC Input	DC/Ohms Relay Assy	$K7 = \overline{M} \cdot \overline{N} \cdot \overline{COS} \cdot (J + \cancel{K})$
K8		DC/Ohms Output	DC/Ohms Relay Assy	$K8 = \overline{M} \cdot \overline{COS} \cdot (J + \cancel{K} + N)$
K9	OHMS	Ohms Input	DC/Ohms Relay Assy	$K9 = K17 = \overline{M} \cdot N \cdot \overline{COS}$
K10		1 KΩ Range	Ohms Major Assy	$K10 = J \cdot N$
K11		10 KΩ Range	Ohms Major Assy	$K11 = \cancel{K} \cdot L \cdot \overline{M} \cdot N$
K12		100 KΩ Range	Ohms Major Assy	$K12 = \cancel{K} \cdot \overline{L} \cdot \overline{M} \cdot N$
K13		1 MΩ/10 MΩ Range	Ohms Major Assy	$K13 = J \cdot \overline{\cancel{K}} \cdot \overline{M}$
K14	LOW	X10 Gain	DC/Ohms Relay Assy	$K14 = J \cdot \overline{N}$
K15		Unity Gain	DC/Ohms Relay Assy	$K15 = \overline{J} + N + COS$
K16		AC/DC/By Low	DC/Ohms Relay Assy	$K16 = \overline{K9} + COS = M + \overline{N} + COS$
K17		Ohms Low	DC/Ohms Relay Assy	$K17 = K9 = \overline{M} \cdot N \cdot \overline{COS}$
K18	THRU-GUARD	J	Through-Guard Assy	$K18 = J$
K19		K	Through-Guard Assy	$K19 = \overline{K2} = K \cdot \overline{BY} = \cancel{K}$
K20		L	Through-Guard Assy	$K20 = K3 = L$
K21		M	Through-Guard Assy	$K21 = K1 = M$
K22		N	Through-Guard Assy	$K22 = \overline{K4} = N$

Table 4-2. Relay Equations

SECTION V

MAINTENANCE

5-1. This section contains procedures to check the performance of the instrument and to adjust it to within specification at the 90-day calibration interval or after maintenance. Performance Checks, Paragraph 5-2, may be used for periodic inspection or incoming quality control. (See Performance Check Test Card at end of section.) Preliminary Adjustments, Paragraph 5-52, are to be accomplished prior to the actual Calibration Adjustments, Paragraph 5-82, at 90-day intervals. Table 5-1 lists the equipment required for the checks and adjustments. Other equipment meeting the critical specifications may be substituted. Also included in this section are troubleshooting and maintenance information. Allow a 15 minute instrument warm-up.

Table 5-1

REQUIRED TEST EQUIPMENT

TYPE	PURPOSE*				CRITICAL SPECIFICATIONS**	RECOMMENDED MODEL
	AC	DC	Ohms	General		
AC Calibrator	c/a				Voltage: .1, 1, 10, 100 volts Acc: 50 Hz to 20 kHz: $\pm(0.022\% + 10\ \mu V)$ 20 kHz to 100 kHz: $\pm(0.055\% + 50\ \mu V)$	-hp- 745A
DC Digital Voltmeter	c/a	c	a	c	Acc: $\pm(0.004\%$ of reading + 0.002 % of full scale) Ranges: 1, 10, 100 V Resolution: 5 digits Input R: 10 MΩ ±0.03%	-hp- 3460B
DC Digital Voltmeter		a			Resolution: 6 digits Range: 10 V Input R: 10 MΩ Stability: 1 μV/min	-hp- 3420B
Counter		a			Function: period measurement Resolution: 4 digits Range: 1 kHz Accuracy: ±0.1%	-hp- 5233L

TYPE	PURPOSE AC	DC	Ohms	General	CRITICAL SPECIFICATIONS**	RECOMMENDED MODEL
Oscilloscope with 10:1 Probe	a	a			Sensitivity: 50 mV/cm (including probe) Input R: 10 MΩ (including probe)	-hp- 140A/ 1400A/1422A/ 10001A
10:1 Voltage Divider		c/a			Acc: ±0.001% R: ≤ 1 MΩ	Julie Research Labs Model VDR106
Null Meter		c	c/a		Range: 3 μV Acc: ±2%	-hp- 419A
Analog AC Voltmeter				c	Acc: ±2% Freq: 2 kHz Range: 10 mV Battery operated	-hp- 403B
1 V Standard			c/a		Acc: ±6 ppm (See Appendix C)	-hp- 735A specially calibrated
Oscillator	c			c	Distortion: ±0.2% Voltage: 10.5 V Freq: 100 Hz to 40 kHz	-hp- 200CD
DC Differential Voltmeter	a	a			Range: 1 mV Acc: ±1% Input R: 10 MΩ	-hp- 412A
Standard Resistors			c/a		Acc:	
1 kΩ					±10 ppm	-hp- 11103A
10 kΩ					±10 ppm	-hp- 11104A
100 kΩ					±10 ppm	4045-B Leeds
1 MΩ					±20 ppm	4045-B and Northrup
500 V DC Source				c		
10 V DC Source		c/a			Stability: 10 μV/min	
1 V DC Adj. Source	c	c			Resolution: 10 μV Adjustability: 10%	
Resistors					Acc:	
1 MΩ		c			±1%	-hp- 0757-0344
100 kΩ	c			c	±0.01%	-hp- 0811-0354
10 kΩ		c			±1%	-hp- 0757-0340

TYPE	PURPOSE*				CRITICAL SPECIFICATIONS**	RECOMMENDED MODEL
	AC	DC	Ohms	General		
Variable Line Transformer	c	c	c		Power: 40 watt Adjustability: 102 V-to-128 V or 207 V-to-253V	Superior Type 115 V: VC1MB 230 V: VC2MB

* Test equipment required is keyed to individual instrument functions, and also according to whether performance checks or adjustments are to be performed.

** Critical Specifications listed are those dictated by either the Checks or Adjustments, whichever has the more stringent requirements on the equipment.

5-2. PERFORMANCE CHECKS

5-3. A Variable Line Transformer as listed in Table 5-1 is to be used on each Accuracy Check to determine immunity from a ±10% line voltage variation.

5-4. AC CONVERTER

5-5. Accuracy.

5-6. Test equipment required: 745A, 3460B.

5-7. Full scale voltages at various frequencies are applied from 745A to 3461A, and the output accuracy monitored by 3460B. Connect 745A to 3461A using remote sensing; i.e., connect HIGH SENSE and HIGH OUTPUT together at HIGH of 3461A, and connect the LO's together at LOW. Interconnect 3461A and 3460B with the Output Cable per Paragraph 3-3.

745A	3461A	3460B
appropriate VOLTAGE RANGE	ACN	1 V RANGE
Voltage Knobs to 1000000	appropriate RANGE	LOCAL TRIGGERING
appropriate FREQUENCY RANGE	FRONT INPUT	RATE clockwise
FREQUENCY vernier to appropriate position		REAR INPUT
0% ERROR RANGE		
REMOTE SENSE		

5-8. Select each voltage and frequency of 745A and range of 3461A as listed below, and observe 3460B for proper readout:

	745A	3461A	3460B		745A	3461A	3460B
a.	100 mV - 1 kHz	1 V	0.1 V ± 16 counts	k.	10 V - 1 kHz	10 V	1 V ± 70 counts
b.	100 mV - 10 kHz	1 V	0.1 V ± 16 counts	l.	10 V - 10 kHz	10 V	1 V ± 70 counts
c.	100 mV -100 kHz	1 V	0.1 V ± 100 counts	m.	10 V - 20 kHz	10 V	1 V ± 95 counts
d.	1 V -50 Hz	1 V	1 V ± 95 counts	n.	10 V -100 kHz	10 V	1 V ± 150 counts
e.	1 V -200 Hz	1 V	1 V ± 70 counts	o.	100 V -200 Hz	100 V	1 V ± 70 counts
f.	1 V -1 kHz	1 V	1 V ± 70 counts	p.	100 V -1 kHz	100 V	1 V ± 70 counts
g.	1 V -3.5 kHz	1 V	1 V ± 70 counts	q.	100 V -3.5 kHz	100 V	1 V ± 70 counts
h.	1 V -10 kHz	1 V	1 V ± 70 counts	r.	100 V -10 kHz	100 V	1 V ± 70 counts
i.	1 V -100 kHz	1 V	1 V ± 150 counts	s.	100 V -20 kHz	100 V	1 V ± 95 counts
j.	10 V -200 Hz	10 V	1 V ± 70 counts	t.	100 V -100 kHz	100 V	1 V ± 150 counts

5-9. Input Impedance.

5-10. Test equipment required: 200CD, 3460B, 100 kΩ ±0.01% resistor.

5-11. The resistance and frequency of an input signal are varied, and the resultant output voltage change monitored by the 3460B to determine the input resistance and capacitance. Interconnect 3461A and 3460B with the Interface Logic Cable and Output Cable per Paragraph 3-3. Connect 200CD to HIGH and LOW of 3461A with the 100 kΩ resistor in series.

200CD	3461A	3460B
100 Hz, then 40 kHz	ACN	REMOTE RANGE
	10 V RANGE	LOCAL TRIGGERING
	FRONT INPUT	RATE clockwise
		REAR INPUT

5-12.

a. Adjust 200CD to 100 Hz, full scale readout on 3460B.

b. Short 100 kΩ. Readout should increase to 10.2 V ±0.1% to verify an input resistance of 5 MΩ ±0.1%. Remove short.

c. Increase 200CD frequency to 40 kHz (21 kHz if rear panel input of 3461A is used). Readout should fall about 3 dB (to 7.07 V) to verify an input capacitance of about 40 pF (75 pF at rear panel).

5-13. Output Resistance.

5-14. Test equipment required: 3460B, 1 V Adjustable Source.

5-15. To measure the output resistance, the load resistance is varied and the resultant output voltage change observed. Interconnect 3461A and 3460B with the

Interface Logic Cable and Output Cable per Paragraph 3-3. Connect 1 V Source to HIGH and LOW of 3461A.

3461A	3460B
ACN	REMOTE, then 1 V RANGE
1 V RANGE	LOCAL TRIGGERING
FRONT INPUT	RATE clockwise
	REAR INPUT

5-16.

a. Select REMOTE RANGE of 3460B, and adjust 1 V Source to give 1.00000 V readout on 3460B.

b. Select 1 V RANGE on 3460B front panel to change 3460B input resistance from $10^7\ \Omega$ to $> 10^{10}\ \Omega$. Readout should increase to 1.02 V ±2% to verify a 3461A output resistance of 220 kΩ ±2%.

5-17. DC PREAMPLIFIER.

5-18. Unity-Gain Accuracy.

5-19. Test equipment required: 419A, 10 V Source.

5-20. The Preamplifier output voltage is compared with the input to determine the unity-gain accuracy. Connect the 10 V Source across HIGH and LOW of 3461A, and connect 419A between front-panel HIGH input and rear-panel HIGH output.

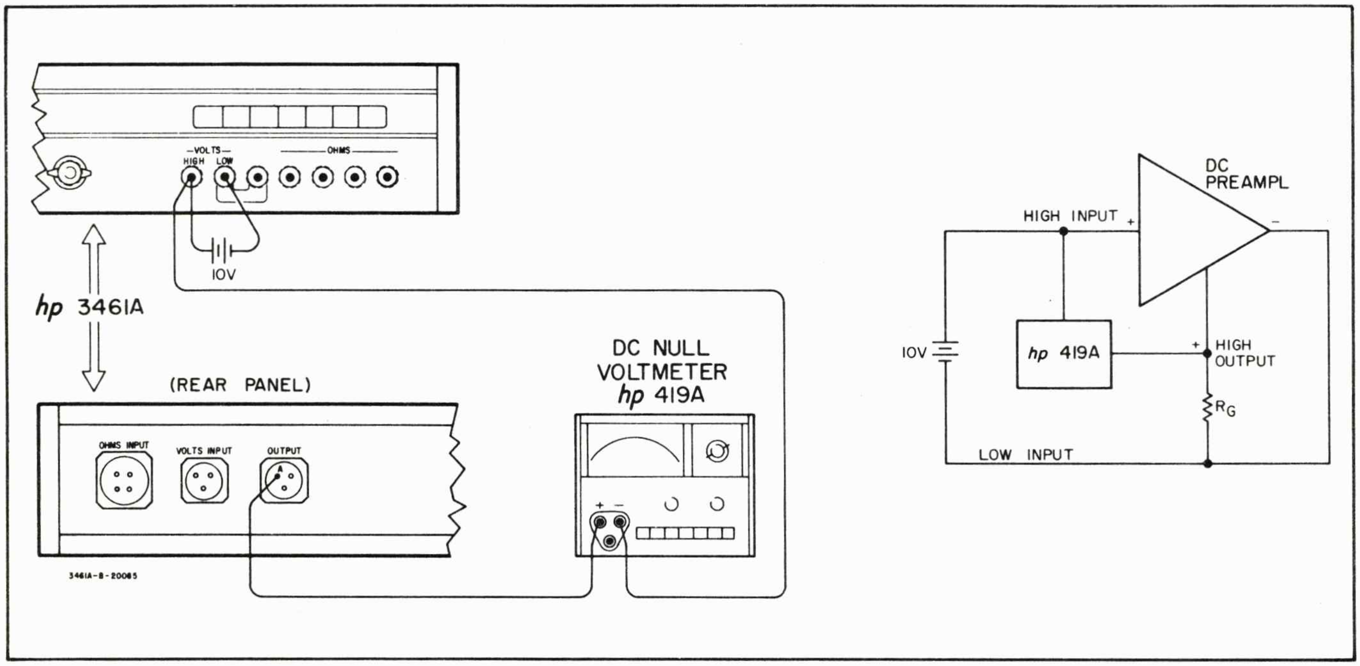


Figure 1. Unity-Gain Accuracy

3461A	419A
DC	VM function
10 V RANGE	appropriate RANGE
FRONT INPUT	

5-21. 419A should indicate less than 300 μV to verify unity-gain accuracy.

5-22. X10-Gain Accuracy.

5-23. Test equipment required: 3460B, 10:1 Voltage Divider, 10 V Source.

5-24. A 10 V Source is first measured by the 3460B directly, and then through the X10 gain of Preamplifier with the 10 V Source divided by 10. Connect 10 V Source across Voltage Divider with 3460B front-panel HIGH and LOW in parallel. Connect the 10:1 division leg of Voltage Divider to 3461A HIGH and LOW. Interconnect 3461A and 3460B with the Output Cable per Paragraph 5-33.

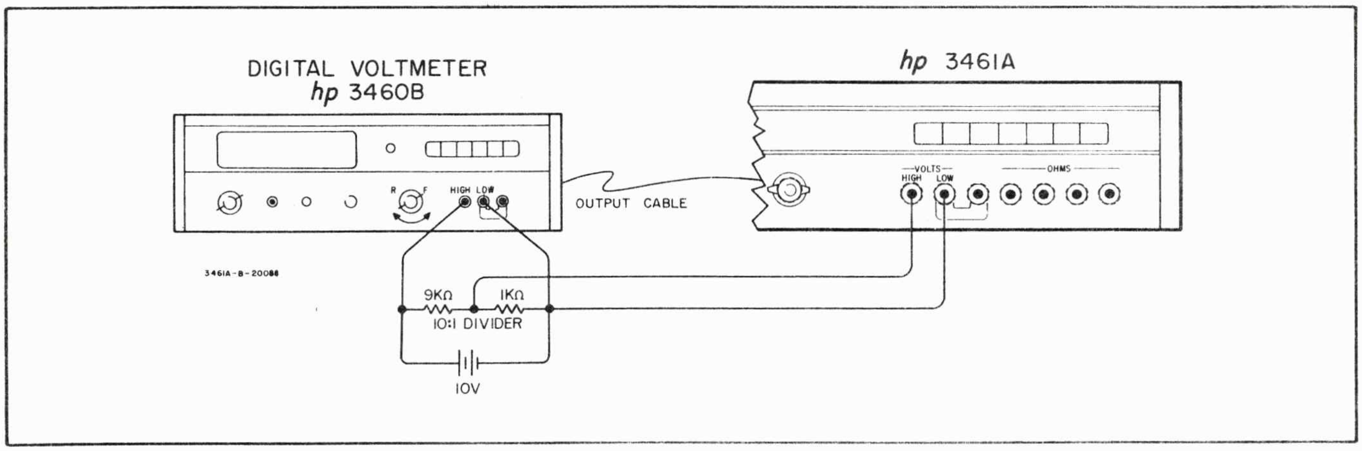


Figure 2. X10-Gain Accuracy

3461A	3460B
DC	10 V RANGE
.1 V RANGE	LOCAL TRIGGERING
FRONT INPUT	RATE clockwise
	FRONT, then REAR INPUT

5-25. Switch between FRONT and REAR input of 3460B. Readout should change less than 5 counts to verify X10 gain of the Preamplifier.

5-26. Input Resistance.

5-27. Test equipment required: 3460B, 10 V Source, 1 MΩ Resistor.

5-28. The input resistance is measured by noting the effect on the output when the source resistance of a 10 V input is changed. Interconnect the 3461A and 3460B with the Interface Logic Cable and Output Cable per Paragraph 3-3. Connect the 10 V Source to HIGH and LOW of 3461A, with the 1 MΩ resistor in series.

3461A	3460B
DC	REMOTE RANGE
10 V RANGE	LOCAL TRIGGERING
FRONT INPUT	RATE clockwise
	REAR INPUT

5-29. Note reading of 3460B, and then short the 1 MΩ resistor. Reading should change less than 10 counts to verify an input resistance of $> 10^{10}\ \Omega$.

5-30. Output Resistance.

5-31. Test equipment required: 3460B, 1 V Source, 10 kΩ Resistor.

5-32. The output resistance is determined by loading the output to draw 100 μA and then measuring the voltage generated across the output resistance due to the current. Connect the 1 V Source to HIGH and LOW of 3461A, and connect 3460B across the output with provision to connect the 10 kΩ resistor in parallel.

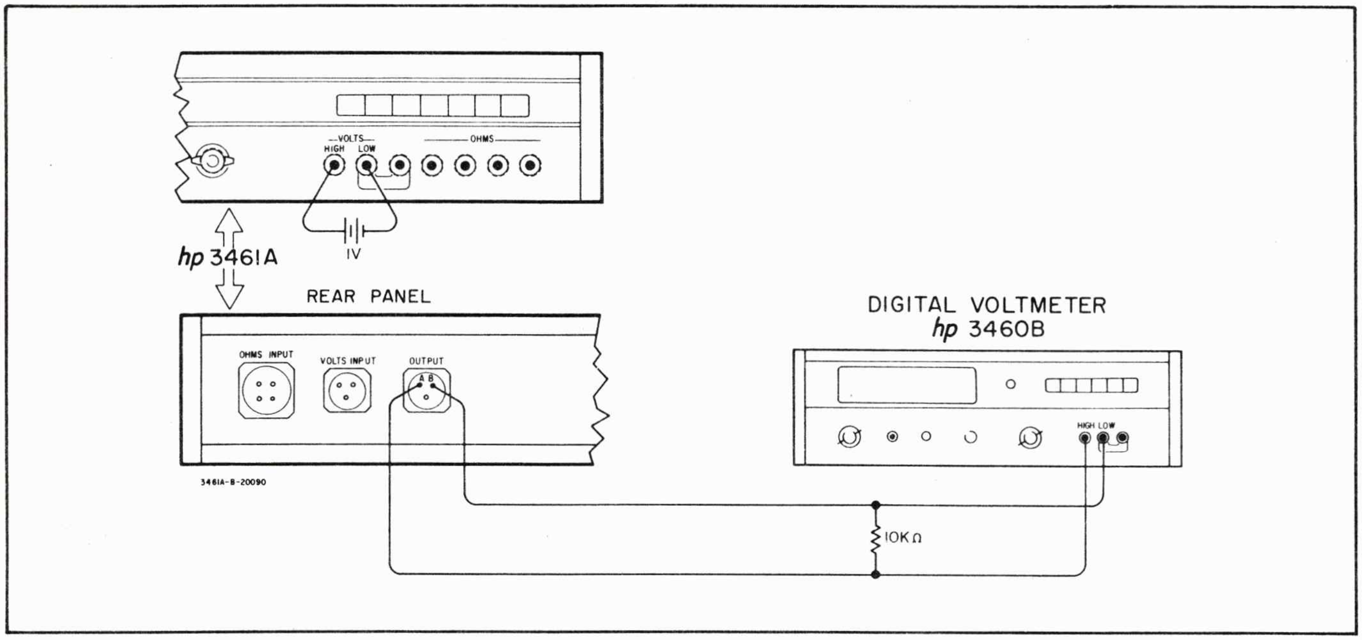


Figure 3. Output Resistance

3461A	3460B
DC	1 V RANGE
1 V RANGE	LOCAL TRIGGERING
FRONT INPUT	RATE clockwise
	FRONT INPUT

5-33. Note reading of 3460B, then connect the 10 kΩ Resistor across the input terminals of 3460B. 3460B reading should change less than 10 counts to verify a Preamplifier output resistance of < 1 Ω.

5-34. Noise.

5-35. Test equipment required: 3460B.

5-36. Output noise on the .1 V range may be determined by monitoring the output over a period of time with the 3460B. Interconnect 3461A and 3460B with the Interface Logic Cable and Output Cable per Paragraph 3-3.

3461A	3460B
DC	REMOTE RANGE
.1 V RANGE	LOCAL TRIGGERING
INPUT OFF	RATE clockwise
	REAR INPUT

5-37.

a. Offset the ZERO adjustment of 3461A until 3460B readout remains positive. No more than four different digits should be observed for the least significant digit over a substantial period of time.

b. Readjust ZERO so that the noise is symmetrical around zero.

5-38. OHMS CONVERTER.

5-39. Accuracy.

5-40. Test equipment required: 419A, 735A (1 V ±10 ppm), 1 kΩ thru 1 MΩ Standard Resistors.

5-41. Ohms accuracy is determined with Standard Resistors as an input and a 419A Null Meter and 735A 1 V Standard as a 1 V output monitor. Connect 419A and 735A in series across the output of J53 pins A and B so that the negative output of 735A is connected to pin B. See Figure 5-8.

3461A	419A	735A
OHMS	VM function	1.000 V function
appropriate RANGE	appropriate RANGE	
FRONT INPUT		

5-42. Connect each Standard Resistor in turn to SENSE and SIGNAL terminals in the four-terminal technique and observe 419A for proper reading as listed below:

	STANDARD RESISTOR	3461A RANGE	419A NULL READING
a.	1 kΩ	1 kΩ	< 100 μV
b.	10 kΩ	10 kΩ	< 100 μV
c.	100 kΩ	100 kΩ	< 100 μV
d.	1 MΩ	1 MΩ	< 140 μV
e.	1 MΩ	10 MΩ	< 320 μV

5-43. GENERAL.

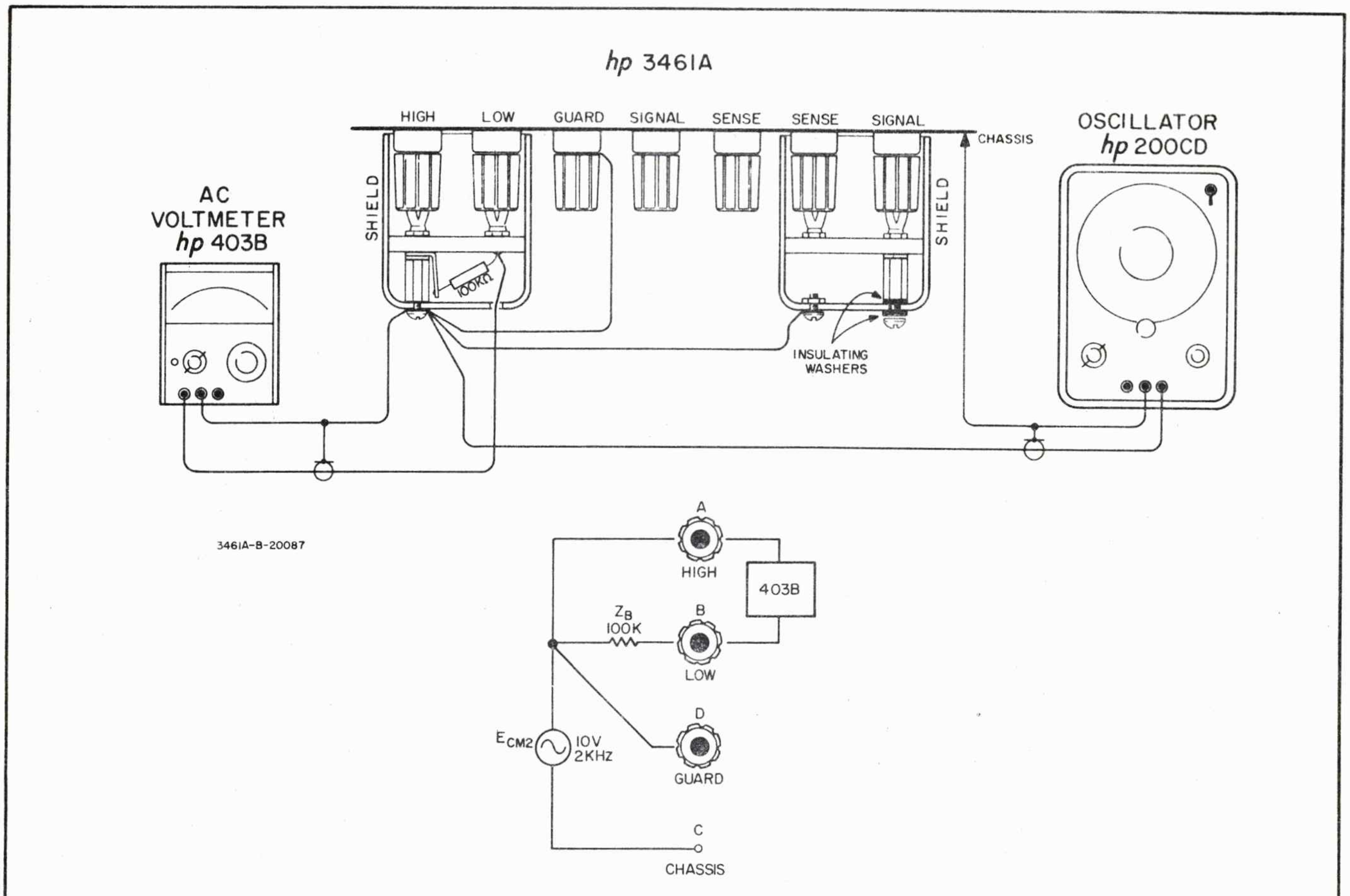
5-44. AC Common-Mode Rejection.

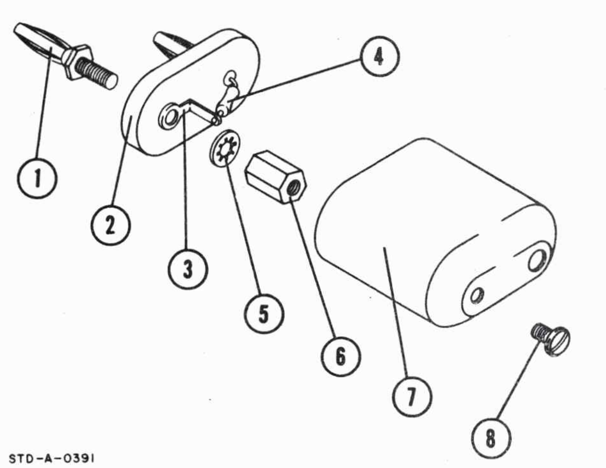
5-45. Test equipment required: 403B, 200CD, 100 kΩ Resistor.

5-46. Superimposed noise due to common-mode voltage is determined by measuring the voltage generated across the source unbalance resistance Z_B between High and Low due to a common-mode voltage driving Low through the same resistance. Connect 403B across 3461A HIGH and LOW to measure the superimposed noise. Connect 200CD between HIGH and instrument chassis for the common-mode voltage. Connect GUARD to HIGH so that it is driven by the same common-mode voltage driving LOW, but so that it does not pass current through Z_B. A shield is needed around the HIGH, LOW and black SIGNAL terminals. Connect both shields to HIGH and insulate the SIGNAL shield from the terminals it mounts on.

3461A	200CD	403B
any FUNCTION	10 V	appropriate RANGE
any RANGE	2 kHz	
FRONT INPUT		

5-47. The 403B should indicate 10 mV or less to confirm a common-mode rejection of 120 dB at 60 Hz with 1 kΩ or less source-unbalance-resistance between Low and Guard.





No.	Description	-hp- Part No.
1	Connector, male	1251-0174
2	Connector, male, w/insulator	1251-0175
3	Lug, terminal 90°	0360-0042
4	Resistor, 100 K Ω, 1/2 w, 1%, metal film	0757-0367
5	Washer, int. lock	2190-0007
6	Spacer, 6-32 threaded	0380-0058
7	Shield	1251-0173
8	Screw, bind. head, 6-32 x 1/4 in.	2470-0001

Figure 4. AC Common-Mode Rejection

5-48. <u>DC Common-Mode Rejection.</u>

5-49. Test equipment required: 3460B, 500 V Source, 100 kΩ Resistor.

5-50. Basically the same setup is used as for the ac common-mode rejection check, except that the 3460B measures the error voltage, and a dc voltage of 500 V is used for the common-mode voltage. Interconnect 3461A and 3460B per Paragraph 3-3.

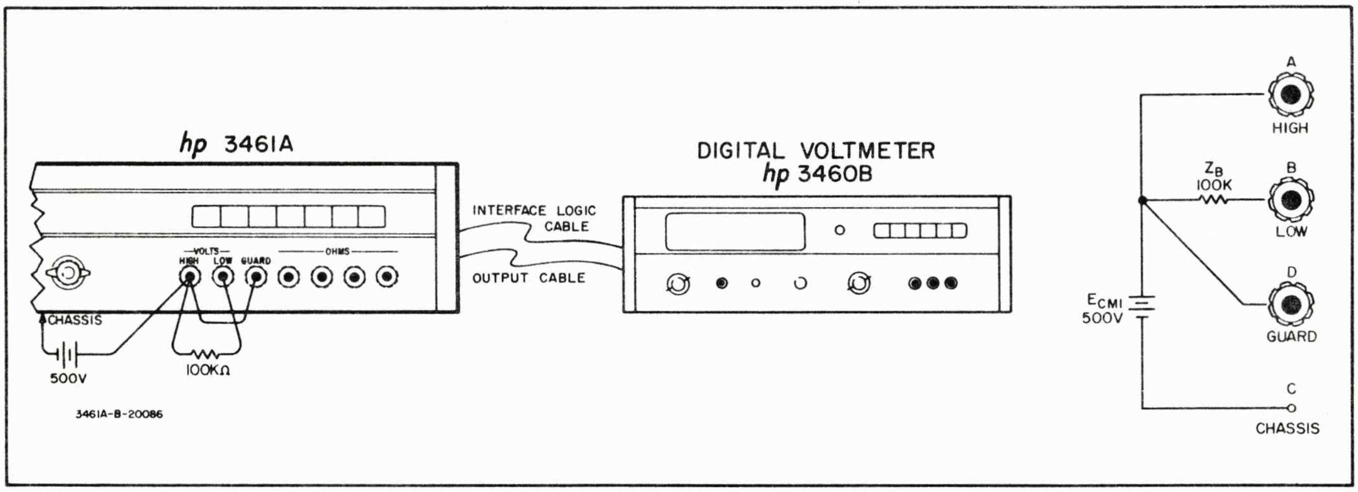


Figure 5. DC Common-Mode Rejection

3461A	3460B
DC, or BYPASS for Option 02	REMOTE RANGE
1 V RANGE	LOCAL TRIGGERING
FRONT INPUT	RATE clockwise
	REAR INPUT

5-51. 3460B should display less than 100 counts to verify a common-mode rejection of 114 dB for the two instruments in parallel (120 dB for the 3461A alone) with 100 kΩ between Low and Guard, or 154 dB (160 dB for the 3461A alone) with 1 kΩ between Low and Guard.

5-52. PRELIMINARY ADJUSTMENTS.

5-53. Adjustments for each instrument function must be accomplished in the order given. See Figure 6 for adjustment points. Handle assemblies only by the extractors.

5-54. AC CONVERTER.

5-55. Final Amplifier Bias And Balance.

5-56. Test equipment required: 140A, 10:1 Probe, 412A.

5-57. Remove Buffer Amplifier A42 and place Final Amplifier A43 on an extender. Connect 140A with 10:1 probe between TP3 A43 and AC common sheet metal ▽.

3461A	140A	412A
ACN	5 mV/cm	appropriate RANGE
1 V RANGE		
FRONT INPUT		

5-58.

a. Adjust Balance A43R15 so that the average value of noise at TP3 is zero.

b. Check voltage at TP2 A45 with 412A. It should be within ±0.25 mV of zero. If not, then replace any missing resistors of Bias Adj, R10 thru R13; measure TP2 again; and then finally remove appropriate resistors according to the following table:

A45 BIAS ADJ

Voltage is measured with all resistors R10 thru R13 in place.

TP2 mV	Remove Resistors			
- 4.65 to - 3.41	R10,	R11,	R12	
- 3.40 to - 1.75	R10,	R11		R13
- 1.74 to - 1.13	R10,	R11		
- 1.12 to - 0.79	R10		R12,	R13
- 0.78 to - 0.58	R10		R12	
- 0.57 to - 0.44	R10			R13
- 0.43 to - 0.34	R10			
- 0.33 to - 0.26		R11,	R12,	R13
- 0.25 to - 0.19		R11,	R12	
less than - 0.19	none			

Table 5-2

c. If Bias Adj was changed in preceeding step, then readjust Balance as in step a.

5-59. Buffer Amplifier Balance.

5-60. Test equipment required: 3460B.

5-61. After the preceding Final Amp Bias and Balance Adjustment, place A43 in normal position and A42 on an extender. Select INPUT OFF.

5-62.

a. Coarsely adjust Balance A43R16 so that TP1 A42 is within ±10 mV of zero as measured with 3460B.

b. Finely adjust Balance so that there is no change of voltage at TP3 A45 as measured with 3460B when 3461A is ranged back and forth between 1 V and 10 V ranges. Use 1 V range of 3460B and mentally average out any jitter encountered on either range of 3461A.

c. Place A42 in normal position.

5-63. DC PREAMPLIFIER.

5-64. Chopper Frequency.

5-65. Test equipment required: 5233L

3461A	5233L
DC	PERIOD A
1 V RANGE	maximum SAMPLE RATE

5-66.

a. Remove top Guard and quickly measure period of chopper frequency at TP1 A33. It should be 4.545 msec ±0.005 msec. If the period is not correct, then adjust Chopper Frequency A33R18 (clockwise increases period).

b. If Chopper frequency was adjusted, then lay top Guard back in position and wait about 3 minutes for temperature to stabilize. Then remove Guard and check period again.

c. Proceed to next adjustment.

5-67. Balance.

5-68. Test equipment required: 140A with 10:1 Probe.

5-69. Place A31 on extenders. Ground TP3 and TP4 to Preamplifier common sheet metal ⏚ . Connect 140A across 3461A output at J53.

3461A	140A
DC	5 V/cm (including probe att)

5-70. Adjust Balance R28 so that the Preamplifier output voltage as viewed on the Oscilloscope is as close to zero as possible. It will be discovered that only a small rotation of R28 will cause the output voltage to jump from the maximum value of one polarity to the other. Correct adjustment is when the voltage is between these values; although, the voltage may drift somewhat after adjustment. Some noise may occur as the adjustment is accomplished.

5-71. Unground TP3 and TP4 for the next adjustment.

5-72. Level.

5-73. Test equipment required: 412A.

5-74. After the preceding Chopper Frequency adjustment, ground Q1 gate on A31 to ⏚ sheet metal.

5-75. Adjust Level R19 so that the voltages at TP1 and TP2 are within 100 mV of each other as measured with the 412A between ⏚ sheet metal and each test point in turn. The adjustment affects TP2 to a greater extent than TP1, and the voltages will become equal at about the +2 V level.

5-76. Unground Q1 gate and replace A31 in normal position.

5-77. OHMS CONVERTER.

5-78. Reference Supply Coarse Adjustment.

5-79. Test equipment required: 3460B.

5-80. This adjustment is normally accomplished only after repair of the Reference Supply on A34 and A36. Components may be replaced on A34; but A36 is not field repairable and must be replaced as a whole unit.

5-81.

a. Center 1 kΩ ADJ A34R24 and place a short across resistors A34R17 thru R21 (from top of R21 to bottom of R17).

b. Measure Reference Voltage with 3460B between top of R21 and ⏚ sheet metal.

c. Remove short across the five resistors and install or remove shorts across the individual resistors as needed to give the proper combination listed in table below:

Table 5-3. Ohms Reference Supply Coarse Adj

Reference Voltage*	Shorts
13.960 to 13.946	1, 2, 3, 4, 5
13.945 to 13.919	2, 3, 4, 5
13.918 to 13.892	1, 3, 4, 5
13.891 to 13.865	3, 4, 5
13.864 to 13.838	1, 2, 4, 5
13.837 to 13.811	2, 4, 5
13.810 to 13.785	1, 4, 5

Table 5-3. Ohms Reference Supply Coarse Adj (Cont'd)

Reference Voltage*	Shorts
13.784 to 13.761	4, 5
13.760 to 13.734	1, 2, 3, 5
13.733 to 13.704	2, 3, 5
13.703 to 13.678	1, 3, 5
13.677 to 13.653	3, 5
13.652 to 13.627	1, 2, 5
13.626 to 13.601	2, 5
13.600 to 13.576	1, 5
13.575 to 13.550	5
13.549 to 13.524	1, 2, 3, 4
13.523 to 13.498	2, 3, 4
13.497 to 13.473	1, 3, 4
13.472 to 13.448	3, 4
13.447 to 13.422	1, 2, 4
13.421 to 13.397	2, 4
13.396 to 13.372	1, 4
13.371 to 13.347	4
13.346 to 13.322	1, 2, 3
13.321 to 13.297	2, 3
13.296 to 13.272	1, 3
13.271 to 13.248	3
13.247 to 13.223	1, 2
13.222 to 13.199	2
13.198 to 13.174	none

* Reference Voltage measured with R17 thru R21 shorted and R24 centered.

5-82. CALIBRATION ADJUSTMENTS.

5-83. Preliminary Adjustments, Paragraph 5-52, are to be accomplished prior to these adjustments that establish the final instrument accuracy. Follow the order given, and use an insulated screwdriver through the top Guard with the top Cover removed.

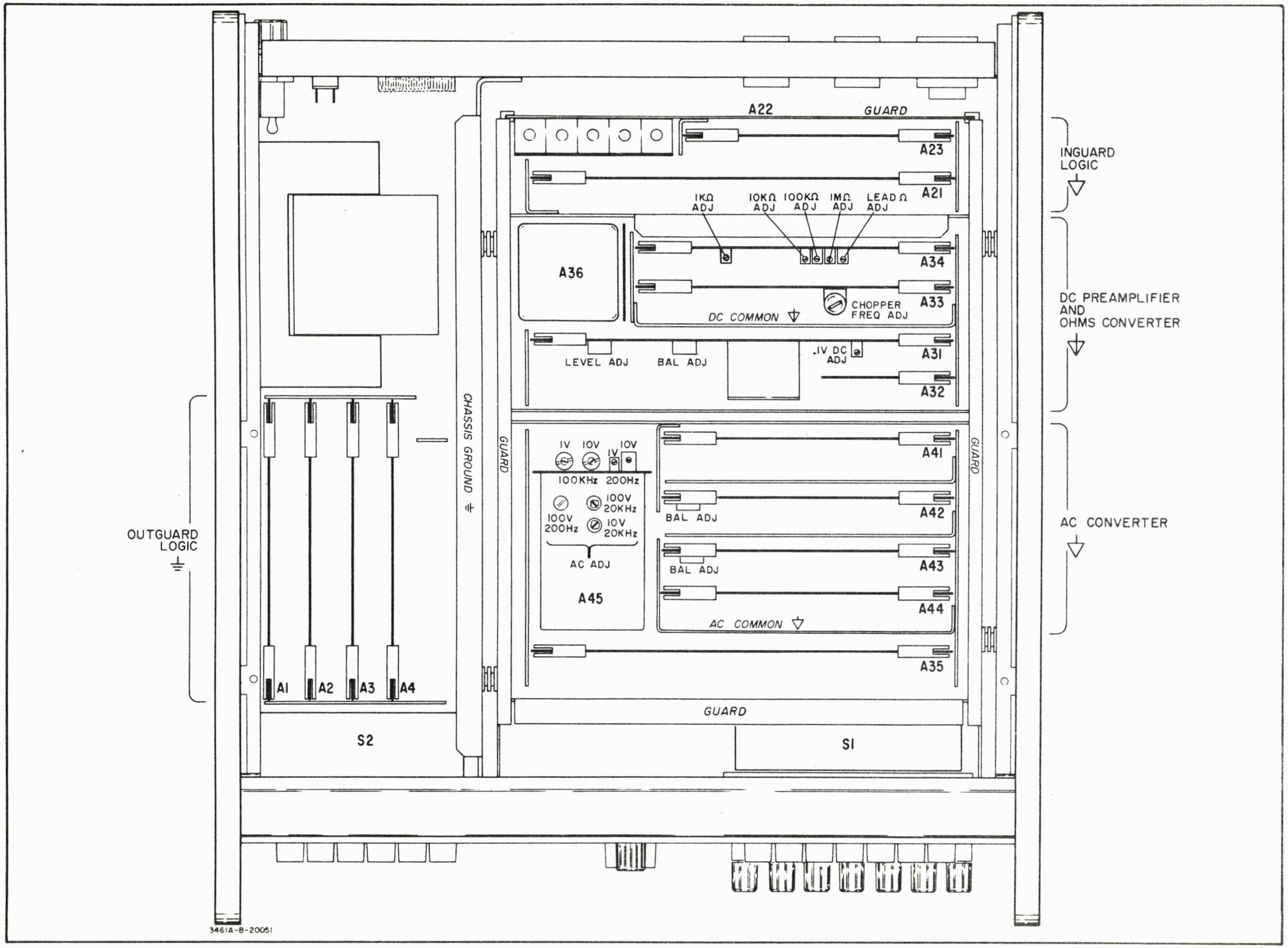


Figure 6. Adjustment Points

5-84. AC CONVERTER.

5-85. Test equipment required: 745A, 3460B.

5-86. Interconnect 3461A and 3460B per Paragraph 3-3. Connect 745A to 3461A using remote sensing; i.e., connect HI SENSE and HI OUTPUT together at HIGH of 3461A, and connect LO's together at LOW.

745A	3461A	3460B
appropriate voltage range	ACN	REMOTE RANGE
Voltage Knobs to 1000000	appropriate RANGE	LOCAL TRIGGERING
appropriate FREQUENCY RANGE	FRONT INPUT	RATE clockwise
FREQUENCY vernier to appropriate position		REAR INPUT
0% ERROR RANGE		
REMOTE SENSE		

5-87. Select each voltage and frequency of 745A and range of 3461A in the order listed below, and make the proper adjustments through the top Guard with an insulated screwdriver for a full scale readout on 3460B.

	745A	3461A		745A	3461A
a.	10 V - 200 Hz	10 V	e.	100 V - 20 kHz	100 V
b.	1 V - 200 Hz	1 V	f.	10 V - 100 kHz	10 V
c.	100 V - 200 Hz	100 V	g.	1 V - 100 kHz	1 V
d.	10 V - 20 kHz	10 V			

5-88. DC PREAMPLIFIER.

5-89. Test equipment required: 3420B, 10:1 Voltage Divider, 10 V Source, Switch.

5-90. Connect 10 V Source and 10:1 Divider in parallel, and the 10:1 division leg of Divider to HIGH and LOW of 3461A. Connect 3420B and Switch so that 3420B can measure either the 10 V Source or 3461A Preamp output.

3461A	3420B
DC	DC∆VM
.1 V RANGE	"+" INPUT POLARITY
OFF, then FRONT INPUT	10 V RANGE
	appropriate SENSITIVITY

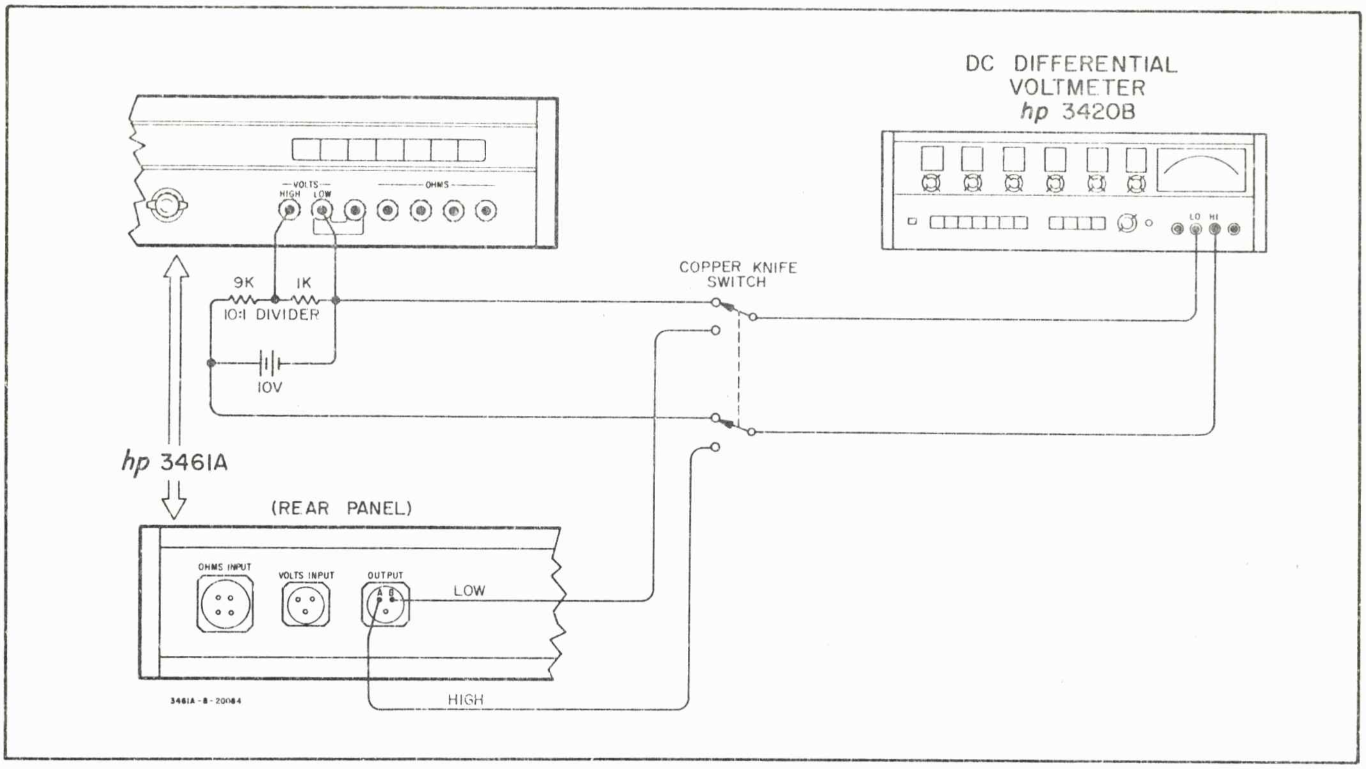


Figure 7. X10-Gain Adjustment

5-91.

a. Select INPUT OFF and switch to the Preamp output. Adjust 3461A ZERO for a zero output to the 3420B on X10^5 SENSITIVITY.

b. Switch 3420B to the 10 V Source and record the reading.

c. Select FRONT INPUT and switch to the Preamp output. Adjust .1 V ADJ through the top Guard using an insulated screwdriver so that the Preamp output is within 10 μV of the 10 V Source.

d. Switch back to the 10 V Source to reaffirm that the voltage has not drifted during the adjustment.

5-92. OHMS CONVERTER.

5-93. Test equipment required: 419A, 735A (specially calibrated to 1 V ±6 ppm), Standard Resistors.

5-94. Adjust 735A as described in Appendix C. Connect "+" INPUT of 419A to High output (J53 pin A) of 3461A; connect "-" INPUT of 419A to "+" OUTPUT of 735A; and connect "-" OUTPUT of 735A to Low output (J53 pin B) of 3461A.

3461A	419A	735A
OHMS	VM function	1.000 V function
appropriate RANGE	appropriate RANGE	
FRONT INPUT		

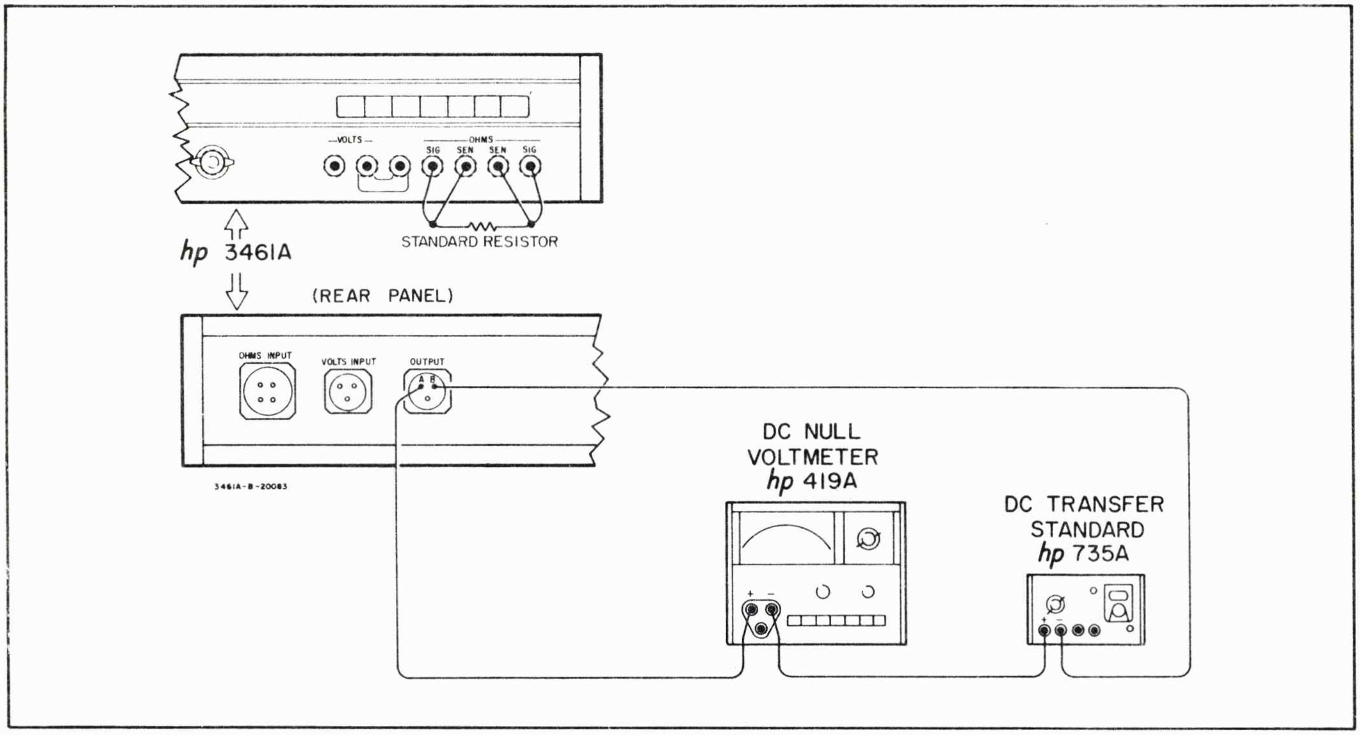


Figure 8. Ohms Accuracy Check and Adjustment

5-95. In ascending order, connect each Standard Resistor to the SENSE and SIGNAL terminals in the four-terminal technique and adjust the 1 kΩ thru 1 MΩ ranges through the top Guard to obtain a null on the 3 μV range of 419A. There is no separate adjustment for the 10 MΩ range.

5-96. TROUBLESHOOTING AND REPAIR.

5-97. Procedures are given in this section to check the performance of individual circuits as an aid in troubleshooting. Also, some repair precautions are given. Do not remove or install assemblies with the power on.

5-98. The inside of the instrument must be kept clean, especially inside the Guard. Be exceptionally careful not to contaminate the following areas with finger prints, dust, or solder rosin:

- Input terminals
- Front/Rear Switch
- DC/Ohms Relay Assy A35
- Preamp input, including A50R1
- Preamp subassy
- Ohms Major Assy A34
- AC Attenuator A45
- Buffer Amp input
- Field-effect transistors

Use clean rubber gloves and handle assemblies only by the extractors or assembly edges.

5-99. To replace components on printed-circuit boards, use a low-heat soldering iron (25 to 50 watts), low-content rosin core solder, and a heat sink. Heat a component

lead only long enough to allow the solder to flow properly into the hole around the lead. Clean the area of excess rosin.

5-100. If the only instrument problem is with accuracy, then it is advisable to first accomplish the Adjustment procedures of Paragraphs 5-52 and 5-82 before looking for component failures. The first step in troubleshooting for faulty components is to determine that the problem is not in the logic circuitry (including associated power supplies) responsible for the range and function selection of the 3461A and 3460B; and only after this, look for malfunctions in the analog circuitry which accomplishes the actual instrument functions.

5-101. If the correct relays of K1 thru K17 close on the proper ranges and functions, and if the 3460B assumes the correct readout and measurement ranges both during manual and automatic ranging, then the logic is all right. Improper operation on only certain ranges of one function or on more than one of the AC, DC, or Bypass functions would implicate the relays or associated drive circuits. Proper ranging of the 3460B is immediately apparent by watching the decimal point and data move across the face as the 3461A is ranged. See Paragraph 5-121, LOGIC.

5-102. AC CONVERTER.

5-103. Final Circuitry.

5-104. Gain. A rough check of the Final Amp Gain can be made with a dual-trace oscilloscope (with 10:1 probes) between A45TP1 and A43TP3. A more accurate check can be made by creating an offset at Q5 stage and observing A43TP3 for a maximum voltage. Remove A42, ground A45TP1, add a 178 Ω resistor across TP1 and TP2, select the 1 V range and check TP3 with an oscilloscope for an average voltage of less than +400 mV. This checks the dc gain of Q1 thru Q5 and verifies that Q6 thru Q7 are operative. Further gain factors are listed below:

A43 Gain

TP1 A45 to TP3 A43
- 1 V/100 V ranges: A = 5 from 50 Hz to 100 kHz
- 10 V/1 kV ranges: A = 1/2 from 50 Hz to 100 kHz

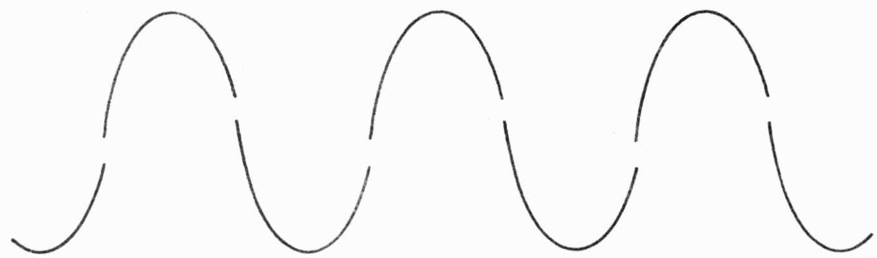
TP1 A45 to Converter output (ac-to-dc)
- 1 V/100 V ranges: A = 2 from 50 Hz to 100 kHz
- 10 V/1 kV ranges: A = 2/10 from 50 Hz to 100 kHz

Q1A base to TP1 A43: A = 52 at 100 Hz
TP1 to Q5 coll: A ≅ 30 at 100 Hz
Q7 base to TP3 A45: A = unity at 100 Hz
TP3 A43 to Q1B base: A = 1/100 at 100 Hz

5-105. Input Bias. See Paragraph 5-55.

5-106. Overload Loop. The signal at A43TP3 should start clipping at about 5 V peak with a symmetry within .25 V if CR1 thru CR8 are all right.

5-107. Rectifier. A sine wave at TP3A43 with .3 V discontinuities on both slopes verifies that CR12 and CR13 are good. Some tilt will exist between the discontinuity points, that varies with frequency.



5-108. Filter. A 3 V peak signal at A43TP3 should give a 1 V output from the filter. To check for capacitor leakage, remove A43 and connect 10 volts dc through a 20 kΩ ±1% resistor to the filter input. Interconnect the 3461A and 3460B with the Output Cable, and connect the 3460B front input to measure the 10 V directly. Switch between FRONT and REAR INPUT of the 3460B and look for a voltage change of < 100 μV on ACN or ACF. (Do not disable High-Z of 3460B.)

5-109. Buffer Circuitry.

5-110. Gain. To roughly check the Buffer Amp gain, use a dual-trace oscilloscope with 10:1 probes between the Converter input and A42TP1. An accurate check of the dc gain can be made as follows: Select INPUT OFF and 1 V RANGE, add a 510 Ω resistor across TP2 and TP3, and check TP1 with an oscilloscope for an average voltage of less than +2 mV. This checks the gain of Q1 thru Q5 and verifies that Q6 thru Q8 are operative. Further gain factors are listed below:

A42 Gain

Converter input to TP1 A42
- 1 V/10 V ranges: A = 1/2 from 50 Hz to 100 kHz
- 100 V/1 kV ranges: A = 1/200 from 50 Hz to 100 kHz

Q1A gate to Q5 base: A ≥ 500 from dc to ≅ 500 Hz
TP2 or Q5 base to TP1: A ≅ 20 from dc to ≅ 500 kHz
Q5 coll to TP1: A = unity from dc to ≅ 500 kHz
Q1A gate to TP1: A = ≥ 10^4 from dc to ≅ 500 Hz

5-111. Q1 Leakage. Select INPUT OFF, 1000 V RANGE. Adjust Balance R16 so that TP1A42 is less than ±150 μV measured with 3460B. Now select 10 V RANGE; TP1 should change < 250 μV if Q1 is not leaky.

5-112. Overload Loop. The signal at A42TP1 should start clipping at about 9 V peak if CR1 thru CR10 are all right. This can be observed on the 1 V range with an 19 V peak input.

5-113. A45C1 Leakage. Apply 100 V dc to the Converter input on 1 V range and check for < 250 μV at A45TP1 measured with 3460B.

5-114. DC PREAMPLIFIER.

5-115. Chopper Amplifier.

To check the gain of the entire Chopper Amp, select DC, INPUT OFF, and adjust front-panel ZERO to change the "zero" voltage by 100 mV at V3. Use an -hp-412A to measure this voltage at the top, left, back pin of the Photochopper subassy or at J31A pin 10. The Preamp output to the 3460B should change < 30 μV as the "zero" voltage is changed. The Main Amp must be functional for this check, but only to the extent that it just passes a signal.

5-116. 1st Amp.

If Q3 can be made to saturate or cutoff by changing the bias of Q1 then the amplifier is probably all right. Saturate Q3 by shorting the gate and source of Q1; cutoff Q3 by shorting R6.

5-117. 2nd Amp.

Level Adj R19 should move TP1 and TP2 voltages in opposite directions, with a gain of about 200 between the two. The voltages when adjusted equal should be about + 2 V.

5-118. Main Amp.

With TP3 and TP4 grounded to ∇, a small adjustment of Balance R28 should move the Preamp output voltage to > 15 V of either polarity.

5-119. Differential Amp.

With A32 removed and TP3 grounded, Balance Adj R28 should move the Differential Amp output at J31A pin 3 from - 15 V to - 25 V.

5-120. Power Supply.

A quick check of the Preamp power supply is to observe the light emitted from the Photochopper subassembly. The light should appear unvarying and of equal intensity at each of the four cells.

5-121. LOGIC.

5-122. S1, S2, Counters, Outguard Driver.

Check at pins 25, 26, 27, 29 and 34 of the Interface Logic Jack J54 to determine that signals J thru N have the correct true or false levels on each function and range according to Table 4-1.

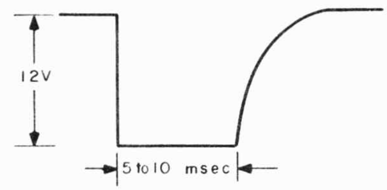
5-123. Through-Guard Relays K18 thru K22.

Remove A21 and A23, and check the resistance between the top reed terminals and the AC sheet metal ▽ when each function and range is selected according to Table 4-1.

5-124. AC/BY, DC/Ω Drivers; K1 thru K17.

5-125. To check the COS one-shot, look for the following waveform at the A21 test point when J, K, M, and N alternate levels:

J alternates between .1 V and 1 V on DC or Ohms
K alternates between 10 V and 100 V
M alternates between ACN and Ohms, not on .1 V
N alternates between ACN and ACF, not on .1 V



This signal should cause relays 5 thru 9 and 17 to open momentarily, and 15 and 16 to close momentarily.

5-126. The remainder of assemblies A21 and A23 is operating properly if the correct combination of relays K1 thru K17 energize according to Table 4-1. Check the drive line voltages, and if these are not"high" or "low" when they should be, then measure the resistance of the relay coils to determine that they are not open, implicating the drive circuits.

5-127. Range Select.

Interconnect the 3461A and 3460B with the Interface Logic Cable. Select REMOTE RANGE and FRONT INPUT of the 3460B and apply 1 Vdc to front input. Now select each range and function of the 3461A in turn to verify that the 3460B goes to the correct measurement range according to Table 4-1. This checks gates 42 and 48 thru 54, assuming that the Counters are all right.

5-128. Auto Inhibit.

The Auto Inhibit is easily checked on the Ohms function by observing the reaction of the 3460B for both an open and a shorted input to the 3461A on Auto Range. With the 3460B and 3461A interconnected per Paragraph 3-3, and the 3461A Ohms input open (each pair of Sense and Signal terminals should be connected though), the TRIGGER and OVERLOAD lamps of the 3460B should flash and the decimal point should move to the third position from the left to indicate that auto-range commands from the 3460B have triggered the 3461A Range Counter through driver 9, and that gates 42 and 43 have generated an Uprange Inhibit and High Range on the 10 MΩ range. With the input shorted, the 3460B should downrange to the second decimal point and trigger normally to indicate that gates 46 and 47 and driver 10 have operated properly. To check gates 44 and 45 the AC or Bypass function must be used. To check gates 42 and 43 on the AC function it is only necessary to apply > 1.2 Vdc to the front input of the 3460B.

PERFORMANCE CHECK TEST CARD

Hewlett-Packard Model 3461A
AC/Ohms Converter-DC Preamplifier

Test performed by ______________
Date ______________

Serial No. ___ - _____

TEST	LIMITS	READING
AC CONVERTER ¶ 5-4		
Accuracy ¶ 5-5		
a. 100 mV - 1 kHz	0.1 V ± 16 counts	________
b. 100 mV - 10 kHz	0.1 V ± 16 counts	________
c. 100 mV - 100 kHz	0.1 V ± 100 counts	________
d. 1 V - 50 Hz	1 V ± 95 counts	________
e. 1 V - 200 Hz	1 V ± 70 counts	________
f. 1 V - 1 kHz	1 V ± 70 counts	________
g. 1 V - 3.5 kHz	1 V ± 70 counts	________
h. 1 V - 10 kHz	1 V ± 70 counts	________
i. 1 V - 100 kHz	1 V ± 150 counts	________
j. 10 V - 200 Hz	1 V ± 70 counts	________
k. 10 V - 1 kHz	1 V ± 70 counts	________
l. 10 V - 10 kHz	1 V ± 70 counts	________
m. 10 V - 20 kHz	1 V ± 95 counts	________
n. 10 V - 100 kHz	1 V ± 150 counts	________
o. 100 V - 200 Hz	1 V ± 70 counts	________
p. 100 V - 1 kHz	1 V ± 70 counts	________
q. 100 V - 3.5 kHz	1 V ± 70 counts	________
r. 100 V - 10 kHz	1 V ± 70 counts	________
s. 100 V - 20 kHz	1 V ± 95 counts	________
t. 100 V - 100 kHz	1 V ± 150 counts	________
Input Impedance ¶ 5-9		
a. resistance	10.2 V ± 0.1%	________
b. capacitance	about 3 dB	________
Output Resistance ¶ 5-13	1.02 V ± 2%	________
DC PREAMP ¶ 5-17		
Accuracy ¶ 5-18, 5-22		
a. Unity Gain	< 300 μV	________
b. X10 Gain	< 5 counts change	________

PERFORMANCE CHECK TEST CARD (Cont'd)

TEST	LIMITS	READING
Input Resistance ¶ 5-26	< 10 counts change	__________
Output Resistance ¶ 5-30	< 10 counts change	__________
Noise ¶ 5-34	≤ 4 digits	__________
OHMS CONVERTER ¶ 5-38		
Accuracy ¶ 5-39		
a. 1 kΩ	< 100 μV	__________
b. 10 kΩ	< 100 μV	__________
c. 100 kΩ	< 100 μV	__________
d. 1 MΩ	< 140 μV	__________
GENERAL ¶ 5-43		
AC CMR ¶ 5-44	< 10 mV	__________
DC CMR ¶ 5-48	< 100 counts	__________

SECTION VI

REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 7-1 lists parts in alphameric order of their reference designators and indicates the description, -hp- part number of each part, together with any applicable notes, and provides the following:

a. Total quantity used in the instrument (TQ column). The total quantity of a part is given the first time the part number appears.

b. Description of the part. (See list of abbreviations below.)

c. Typical manufacturer of the part in a five-digit code. (See Appendix A for list of manufacturers.)

d. **Manufacturer's part number.**

6-3. Miscellaneous parts are listed at the end of Table 7-1.

6-4. ORDERING INFORMATION.

6-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office. (See Appendix B for list of office locations.) Identify parts by their Hewlett-Packard part numbers. Include instrument model and serial numbers.

6-6. NON-LISTED PARTS.

6-7. To obtain a part that is not listed, include:

a. Instrument model number.

b. Instrument serial number.

c. Description of the part.

d. **Function and location of the part.**

DESIGNATORS

A	= assembly	F	= fuse	MP	= mechanical part	TC	= thermocouple
B	= motor	FL	= filter	P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
BT	= battery	HR	= heater	Q	= transistor		
C	= capacitor	J	= jack	QCR	= transistor-diode	W	= cable
CR	= diode	K	= relay	R	= resistor	X	= socket
DL	= delay line	L	= inductor	RT	= thermistor	XDS	= lampholder
DS	= lamp	M	= meter	S	= switch	XF	= fuseholder
E	= misc electronic part	MC	= microcircuit	T	= transformer	Z	= network

ABBREVIATIONS

Ag	= silver	ID	= inside diameter	ns	= nanosecond (s) = 10^{-9} seconds	sl	= slide
Al	= aluminum	impg	= impregnated			SPDT	= single-pole double-throw
A	= ampere (s)	incd	= incandescent	nsr	= not separately replaceable		
Au	= gold	ins	= insulation (ed)			SPST	= single-pole single-throw
C	= capacitor	kΩ	= kilohm (s) = 10^{+3} ohms	Ω	= ohm (s)		
cer	= ceramic			obd	= order by description	Ta	= tantalum
coef	= coefficient	kHz	= kilohertz = 10^{+3} hertz	OD	= outside diameter	TC	= temperature coefficient
com	= common					TiO_2	= titanium dioxide
comp	= composition	L	= inductor	p	= peak		
conn	= connection	lin	= linear taper	pc	= printed circuit	tog	= toggle
dep	= deposited	log	= logarithmic taper			tol	= tolerance
DPDT	= double-pole double-throw	m	= milli = 10^{-3}	pF	= picofarad (s) = 10^{-12} farads	trim	= trimmer
						TSTR	= transistor
DPST	= double-pole single-throw	mA	= milliampere (s) = 10^{-3} amperes	piv	= peak inverse voltage	V	= volt (s)
				p/o	= part of	vacw	= alternating current working voltage
		MHz	= megahertz = 10^{+6} hertz	pos	= position (s)		
elect	= electrolytic	MΩ	= megohm (s) = 10^{+6} ohms	poly	= polystyrene	var	= variable
encap	= encapsulated	met flm	= metal film	pot	= potentiometer	vdcw	= direct current working voltage
		mfr	= manufacturer	p-p	= peak-to-peak		
F	= farad (s)	mtg	= mounting	ppm	= parts per million		
FET	= field effect transistor	mV	= millivolt (s) = 10^{-3} volts	prec	= precision (temperature coefficient, long term stability, and/or tolerance)	W	= watt (s)
fxd	= fixed	μ	= micro = 10^{-6}			w/	= with
GaAs	= gallium arsenide	μV	= microvolt (s) = 10^{-6} volts			wiv	= working inverse voltage
GHz	= gigahertz = 10^{+9} hertz	my	= Mylar ®			w/o	= without
						ww	= wirewound
gd	= guard (ed)	nA	= nanoampere (s) = 10^{-9} amperes	R	= resistor	*	= optimum value selected at factory, average value shown (part may be omitted)
Ge	= germanium			Rh	= rhodium		
grd	= ground (ed)	NC	= normally closed	rms	= root-mean-square		
		Ne	= neon	rot	= rotary		
H	= henry (ies)	NO	= normally open				
Hg	= mercury	NPO	= negative positive zero (zero temperature coefficient)	Se	= selenium	**	= no standard type number assigned (selected or special type)
Hz	= hertz (cycle (s) per second)			sect	= section (s)		
				Si	= silicon		

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REV F

Table 6-1. Replaceable Parts

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A1	03461-66501			**OUTGUARD DRIVER ASSY**	-hp-	
CR1 thru CR23	1901-0081		206	Diode: Si 50 wiv 10 ns 6 pF	01295	obd
Q1	1854-0071		33	TSTR: Si NPN	01295	SK1124
Q2	1853-0092		25	TSTR: Si PNP	04713	obd
Q3	1854-0071		69	TSTR: Si NPN	01295	SK1124
Q4	1853-0092			TSTR: Si PNP	04713	obd
Q5	1854-0071			TSTR: Si NPN	01295	SK1124
Q6	1853-0092			TSTR: Si PNP	04713	obd
Q7	1854-0071			TSTR: Si NPN	01295	SK1124
Q8	1853-0092			TSTR: Si PNP	04713	obd
Q9	1854-0071			TSTR: Si NPN	01295	SK1124
Q10	1853-0092			TSTR: Si PNP	04713	obd
R1 thru R5	1810-0012		55	R: network 8 fxd resistors (A thru H)	56289	obd
R6	0683-1545		2	R: fxd comp 150 kΩ ±5% 1/4 W	01121	CB1545
A2	03461-66502			**AUTO INHIBIT, RANGE SELECT ASSY**	-hp-	
C1, C2	0160-0195		2	C: fxd cer 0.001 μF ±20% 250 vacw	56289	19C251A
CR1 thru CR5	1901-0081			Diode: Si 50 wiv 10 ns 6 pF	01295	obd
CR7 thru CR35	1901-0081			Diode: Si 50 wiv 10 ns 6 pF	01295	obd
Q1	1853-0092			TSTR: Si PNP	04713	obd
Q2, Q3	1854-0071			TSTR: Si NPN	01295	SK1124
Q4	1853-0092			TSTR: Si PNP	04713	obd
Q5, Q6	1854-0071			TSTR: Si NPN	01295	SK1124
Q7 thru Q11	1853-0092			TSTR: Si PNP	04713	obd
R1 thru R5	1810-0012			R: network 8 fxd resistors (A thru H)	56289	obd
R6	0683-1045		9	R: fxd comp 100 kΩ ±5% 1/4 W	01121	CB1045
R7	0683-1335		3	R: fxd comp 13 kΩ ±5% 1/4 W	01121	CB1335
R8	0683-3335		11	R: fxd comp 33 kΩ ±5% 1/4 W	01121	CB3335
R9, R10	0683-1035		20	R: fxd comp 10 kΩ ±5% 1/4 W	01121	CB1035
R11	0683-1045			R: fxd comp 100 kΩ ±5% 1/4 W	01121	CB1045
R12	0683-3335			R: fxd comp 33 kΩ ±5% 1/4 W	01121	CB3335
A3	03461-66503			**RANGE AND FUNCTION COUNTER ASSY**	-hp-	
C1 thru C10	0150-0086		10	C: fxd cer 0.0047 μF ±20% 500 vdcw	56289	29C333
CR1 thru CR58	1901-0081			Diode: Si 50 wiv 10 ns 6 pF	01295	obd
Q1 thru Q10	1854-0071			TSTR: Si NPN	01295	SK1124
R1 thru R5	1810-0012			R: network 8 fxd resistors (A thru H)	56289	obd
R6, R7	0683-1045			R: fxd comp 100 kΩ ±5% 1/4 W	01121	CB1045
R8, R9	0683-1835		9	R: fxd comp 18 kΩ ±5% 1/4 W	01121	CB1835
R10, R11	0683-1045			R: fxd comp 100 kΩ ±5% 1/4 W	01121	CB1045
R12, R13	0683-1835			R: fxd comp 18 kΩ ±5% 1/4 W	01121	CB1835
A4	03461-66504			**AUTO BUFFER, 'NO' DRIVER, OUTGUARD LOGIC P.S. ASSY**	-hp-	
C1	0180-1819		2	C: fxd Al elect 100 μF +75% -10% 50 vdcw	56289	30D107G050DH2-DSM

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
C4	0150-0012		2	C: fxd cer 10,000 pF ±20% 1000 vdcw	56289	29C214A3
C5	0180-0101		7	C: fxd Ta elect 1.8 μF ±10% 35 vdcw	56289	150D185X9035B2
C6	0180-0116		4	C: fxd Ta elect 6.8 μF 35 vdcw	56289	150D685X9035B2
C7	0160-0195		2	C: fxd cer 1000 pF ±20% 250 vacw	56289	19C251A
C8	0180-1819			C: fxd Al elect 100 μF +75% -10% 50 vdcw	56289	30D107G050DH2-DSM
C11	0150-0012			C: fxd cer 10,000 pF ±20% 1000 vdcw	56289	29C214A3
C12	0160-0195			C: fxd cer 1000 pF ±20% 250 vacw	56289	19C251A
C13	0180-0101			C: fxd Ta elect 1.8 μF ±10% 35 vdcw	56289	150D185X9035B2
C14	0180-0116			C: fxd Ta elect 6.8 μF ±10% 35 vdcw	56289	150D685X9035B2
CR1 thru CR6	1901-0081			Diode: Si 50 wiv 10 ns 6 pF	01295	obd
CR9 thru CR11	1901-0081			Diode: Si 50 wiv 10 ns 6 pF	01295	obd
CR12 thru CR15	1901-0158		4	Diode: 200 piv	04713	SR1358-3
CR16	1902-3073		1	Diode: breakdown 4.32 V ±5% 400 mW	07910	CD35601
CR17	1902-3114		2	Diode: breakdown 6.19 V ±2% 400 mW	04713	SZ10939-123
CR18	1901-0081			Diode: Si 50 wiv 10 ns 6 pF	01295	obd
CR20	1902-3114			Diode: breakdown 6.19 V ±2% 400 mW	04713	SZ10939-123
CR21	1901-0081			Diode: Si 50 wiv 10 ns 6 pF	01295	obd
CR22	1902-0025		1	Diode: breakdown 10 V ±5% 400 mW	04713	SZ10939-182
Q1	1853-0092			TSTR: Si PNP	04713	obd
Q2	1854-0072		1	TSTR: Si NPN 2N3054	86684	2N3054
Q3 thru Q5	1854-0215		3	TSTR: Si NPN 2N3904	04713	obd
Q6	1853-0052		1	TSTR: Si PNP 2N3740	04713	obd
Q7, Q8	1853-0092			TSTR: Si PNP	04713	obd
Q9	1854-0071			TSTR: Si NPN	01295	SK1124
Q10	1853-0092			TSTR: Si PNP	04713	obd
Q11	1854-0071			TSTR: Si NPN	01295	SK1124
Q12, Q13	1853-0092			TSTR: Si PNP	04713	obd
	03461-01102		2	Heat sink	-hp-	
R1, R2	1810-0012			R: network 8 fxd resistors (A thru H)	56289	obd
R6	0683-1035		2	R: fxd comp 10 kΩ ±5% 1/4 W	01121	CB1035
R7	0683-3915		2	R: fxd comp 390 Ω ±5% 1/4 W	01121	CB3915
R8	0683-3335			R: fxd comp 33 kΩ ±5% 1/4 W	01121	CB3335
R9	0757-0984		3	R: fxd met flm 10 Ω ±1% 1/2 W	75042	CEC T-O obd
R10	0683-4715		2	R: fxd comp 470 Ω ±5% 1/4 W	01121	CB4715
R11	0683-1235			R: fxd comp 12 kΩ ±5% 1/4 W	01121	CB1235
R12	0683-0755		2	R: fxd comp 7.5 Ω ±5% 1/4 W	01121	CB75G5
R13	0757-0289		2	R: fxd prec met flm 13.3 kΩ ±1% 1/8 W	75042	CEA T-O obd
R14	0757-0438		2	R: prec met flm 5110 Ω ±1% 1/8 W	75042	CEA T-O obd
R15	0683-1035			R: fxd comp 10 kΩ ±5% 1/4 W	01121	CB1035
R16	0683-3915			R: fxd comp 390 Ω ±5% 1/4 W	01121	CB3915
R17	0683-3335			R: fxd comp 33 kΩ ±5% 1/4 W	01121	CB3335
R18	0757-0984			R: fxd met flm 10 Ω ±1% 1/2 W	75042	CEC T-O obd
R19	0683-4715			R: fxd comp 470 Ω ±5% 1/4 W	01121	CB4715
R20	0683-1235			R: fxd comp 12 kΩ ±5% 1/4 W	01121	CB1235
R21	0683-0755			R: fxd comp 7.5 Ω ±5% 1/4 W	01121	CB75G5
R22	0757-0289			R: fxd prec met flm 13.3 kΩ ±1% 1/8 W	75042	CEA T-O obd
R23	0757-0438			R: fxd prec met flm 5110 Ω ±1% 1/8 W	75042	CEA T-O obd
R24	0757-0427		1	R: fxd met flm 1500 Ω ±1% 1/8 W	75042	CEA T-O obd

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A21	03461-66521			**DC/BYPASS DRIVER, INGUARD LOGIC P.S. ASSY**	-hp-	
C1, C2	0150-0096		5	C: fxd cer 0.05 μF + 80% - 20% 100 vdcw	72982	845-X5V-503Z
C3 thru C10	0160-0153		9	C: fxd my 0.001 μF ±10% 200 vdcw	56289	192P10292-PTS
C11	0180-1735			C: fxd Ta elect 0.22 μF ±10% 35 vdcw	56289	150D224X9035A2-DYS
C12	0180-1819		1	C: fxd Al elect 100 μF +75% -10% 50 vdcw	56289	30D107G050DH2-DSM
C13	0180-1719		1	C: fxd Ta elect 22 μF ±10% 25 vdcw	56289	109D226X9025C2
C14 thru C16	0150-0096			C: fxd cer 0.05 μF +80% -20% 100 vdcw	72982	845-X5V-503Z
C17	0180-0101		1	C: fxd Ta elect 1.8 μF ±10% 35 vdcw	56289	150D185X9035B2
C18	0160-0153			C: fxd my 0.001 μF ±10% 200 vdcw	56289	192P10292-PTS
C19	0180-0116		1	C: fxd Ta elect 6.8 μF ±10% 35 vdcw	56289	150D685X9035B2-DYS
CR1 thru CR23	1901-0081			Diode: Si 50 wiv 10 ns 6 pF	01295	obd
CR24 thru CR28	1901-0026			Diode: Si 200 piv	04713	SR 1358-8
CR29	1902-3073		1	Diode: breakdown 4.32 V ±5% 400 mW	07910	CD35601
CR30	1902-3114		1	Diode: breakdown 6.19 V ±2% 400 mW	04713	SZ10939-123
CR31	1902-0025		1	Diode: breakdown 10 V ±5% 400 mW	04713	SZ10939-182
CR32	1901-0081			Diode: Si 50 wiv 10 ns 6 pF	01295	obd
CR33	1902-0041		1	Diode: breakdown 5.11 V ±5% 400 mW	07910	CD35622
Q1 thru Q8	1854-0071			TSTR: Si NPN	01295	SK1124
Q9	1853-0092			TSTR: Si PNP	04713	obd
Q10	1854-0072		1	TSTR: Si NPN 2N3054	86684	2N3054
Q11, Q12	1854-0215		2	TSTR: Si NPN 2N3904	04713	obd
R1 thru R4	1810-0012			R: network 8 fxd resistors (A thru H)	56289	obd
R5, R6	0683-1025		2	R: fxd comp 1000 Ω ±5% 1/4 W	01121	CB1025
R7	0683-1225		1	R: fxd comp 1200 Ω ±5% 1/4 W	01121	CB1225
R8, R9	0683-5115		2	R: fxd comp 510 Ω ±5% 1/4 W	01121	CB5115
R10 thru R13	0683-1835		6	R: fxd comp 18 kΩ ±5% 1/4 W	01121	CB1835
R14	0683-3335		2	R: fxd comp 33 kΩ ±5% 1/4 W	01121	CB3335
R17	0683-1035			R: fxd comp 10 kΩ ±5% 1/4 W	01121	CB1035
R18	0683-3915		1	R: fxd comp 390 Ω ±5% 1/4 W	01121	CB3915
R19	0683-3335			R: fxd comp 33 kΩ ±5% 1/4 W	01121	CB3335
R20	0757-0984		1	R: fxd met flm 10 Ω ±1% 1/2 W	75042	CEC T-O obd
R21	0683-2025		1	R: fxd comp 2000 Ω ±5% 1/4 W	01121	CB2025
R22	0683-1235		1	R: fxd comp 12 kΩ ±5% 1/4 W	01121	CB1235
R23	0683-4715		1	R: fxd comp 470 Ω ±5% 1/4 W	01121	CB4715
R24	0683-0755		1	R: fxd comp 7.5 Ω ±5% 1/4 W	01121	CB75G5
R25	0757-0289		1	R: fxd prec met flm 13.3 kΩ ±1% 1/8 W	75042	CEA T-O obd
R26	0757-0438		1	R: fxd prec met flm 5110 Ω ±1% 1/4 W	75042	CEA T-O obd
R27	0683-5125		1	R: fxd comp 5100 Ω ±5% 1/4 W	01121	CB5125
R28, R29	0683-1835			R: fxd comp 18 kΩ ±5% 1/4 W	01121	CB1835
A22	03461-66522			**THROUGH-GUARD RELAY ASSY**	-hp-	
K18 thru K22				Relay	-hp-	
	9100-1356		5	Coil	-hp-	
	0490-0401		5	Switch: reed	95348	MR-456
	0360-0464		10	Terminal: lug turret type	10454	5600-2

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
A23	03461-66523			**DC/OHMS DRIVER ASSY**	-hp-	
C1 thru C3	0150-0096		3	C: fxd cer 0.05 µF + 80% - 20% 100 vdcw	91418	Type TA
CR1 thru CR14	1901-0081			Diode: Si 50 wiv 10 ns 6 pF	01295	obd
CR16 thru CR39	1901-0081			Diode: Si 50 wiv 10 ns 6 pF	01295	obd
CR41 thru CR44	1901-0081			Diode: Si 50 wiv 10 ns 6 pF	01295	obd
Q1 thru Q10	1854-0071		10	TSTR: Si NPN	01295	SK1124
R1 thru R5	1810-0012			R: network 8 fxd resistors (A thru H)	56289	obd
R6 thru R12	0683-5115		7	R: fxd comp 510 Ω ± 5% 1/4 W	01121	CB5115
R13	0683-1225		1	R: fxd comp 1200 Ω ± 5% 1/4 W	01121	CB1225
A31	03461-66531			**DC MAJOR ASSY**	-hp-	
A31-1	1990-0221		1	Subassembly (Photochopper-Rectifier)	-hp-	
C1	0170-0029		1	C: fxd poly 0.01 µF ±10% 50 vdcw	56289	P148073
C2	0160-2291		1	C: fxd my 0.18 µF ±10% 80 vdcw	56289	192P1849R8-PTS
C3	0160-2611		2	C: fxd my 1 µF ±10% 50 vdcw	84411	X663F
C4	0180-1719		1	C: fxd Ta elect 22 µF ±10% 25 vdcw	56289	109D226X9025C2
C5	0150-0121			C: fxd cer 0.1 µF +80% -20% 50 vdcw	56289	5C50B1
C6	0160-2611			C: fxd my 1 µF ±10% 50 vdcw	84411	X663F
C7	0170-0079		1	C: fxd my die 0.047 µF ±20% 50 vdcw	84411	601PE
C8	0180-0294		1	C: fxd Ta elect 390 µF ±20% 10 vdcw	56289	109D397X001DT2
C9	0150-0121			C: fxd cer 0.1 µF +80% -20% 50 vdcw	56289	5C50B1
C10	0160-3044		1	C: fxd 0.1 µF ±10% 50 vdcw	000LP	KA1003FK50K
C11	0160-0938			C: fxd mica 1000 pF ±5%	04062	RDM15E102J1C
C12	0160-0205		1	C: fxd mica 10 pF ±5%	04062	RDM15C100J5S
C13	0160-0362		2	C: fxd mica 510 pF ±5%	04062	RDM15F511J3C
C14	0140-0198		1	C: fxd mica 200 pF ±5% 300 vdcw	04062	RDM15F201J3C
C15, C16	0150-0093		2	C: fxd cer 0.01 µF +80% -20% 100 vdcw	91418	TA obd
C17	0150-0121			C: fxd cer 0.1 µF +80% -20% 50 vdcw	56289	5C50B1
C18	0180-0374		1	C: fxd Ta elect 10 µF ±10% 20 vdcw	56289	150D106X9020B2
C19	0180-0196		1	C: fxd Ta elect 56 µF ±10% 15 vdcw	56289	150D566X9015R2
C20	0180-1735		1	C: fxd Ta elect 0.22 µF ±10% 35 vdcw	56289	150D224X9035A2-DYS
CR1, CR2	1901-0156		4	Diode: Si 50 mA at +1 V 20 wiv	01281	PS5553
CR3 thru CR6	1901-0040		4	Diode: Si 30 mA at +1 V 30 piv 12 pF 2 ns	07910	CS6319
CR7, CR8	1902-0022		2	Diode: breakdown 400 mW	07910	CD35540
CR9	1902-3189		1	Diode: breakdown 13 V ±10% 400 mW	04713	SZ10939-214
CR10, CR11	1901-0156			Diode: Si 50 mA at +1 V 20 wiv	01281	PS5553
Q1	1855-0044		1	TSTR: FET N channel	000LP	UC240
Q2, Q3	1853-0036		5	TSTR: Si PNP 2N3906	04713	2N3906-5
Q4	1854-0226		1	TSTR: Si NPN TN56	56289	TN-56
Q5	1853-0036			TSTR: Si PNP 2N3906	04713	2N3906-5
Q7, Q8	1855-0043		1	TSTR: FET N channel matched pair	000LP	S-1131
Q9, Q10	1853-0036			TSTR: Si PNP 2N3906	04713	2N3906-5
Q11, Q12	1854-0071			TSTR: Si NPN 2N3391	04713	MPS 3391-5
R1	0757-0458		1	R: fxd prec met flm 51.1 kΩ ±1% 1/8 W	75042	CEA T-O obd
R2	0683-1545		1	R: fxd comp 150 kΩ ±5% 1/4 W	01121	CB1545
R3	0757-0472		1	R: fxd met flm 200 kΩ ±1% 1/8 W	75042	CEA T-O obd

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
R4	0730-0144		1	R: fxd C flm 10.52 MΩ ±1% 1 W	91637	DC-1
R5	0757-0447		1	R: fxd met flm 16.2 kΩ ±1% 1/8 W	75042	CEA T-O obd
R6	0811-1334		1	R: fxd prec ww 1350 Ω ±1% 3 W	91637	RS2B-95
R7	0683-5625			R: fxd comp 5600 Ω ±5% 1/4 W	01121	CB5625
R8	0683-7525		1	R: fxd comp 7500 Ω ±5% 1/4 W	01121	CB7525
R9	0683-1845		1	R: fxd comp 180 kΩ ±5% 1/4 W	01121	CB1845
R10	0757-0454		1	R: fxd prec met flm 33.2 kΩ ±1% 1/8 W	75042	CEA T-O obd
R11	0757-0416		1	R: fxd prec met flm 511 Ω ±1% 1/8 W	19701	MF5C T-O obd
R12	0683-2435		1	R: fxd comp 24 kΩ ±5% 1/4 W	01121	CB2435
R13	0757-0200		1	R: fxd prec met flm 5620 Ω ±1% 1/2 W	19701	MF5C T-O obd
R14	0683-5635		1	R: fxd comp 56 kΩ ±5% 1/4 W	01121	CB5635
R15	0683-1035		2	R: fxd comp 10 kΩ ±5% 1/4 W	01121	CB1035
R16	0683-5135		1	R: fxd comp 51 kΩ ±5% 1/4 W	01121	CB5135
R17	0683-3315		1	R: fxd comp 330 Ω ±5% 1/4 W	01121	CB3315
R18	0683-5625			R: fxd comp 5600 Ω ±5% 1/4 W	01121	CB5625
R19	2100-1775		1	R: var ww 5000 Ω ±10% 1/2 W (Level Adj)	75042	Type 500
R20	0683-2725		1	R: fxd comp 2700 Ω ±5% 1/4 W	01121	CB2725
R21	0683-6835		1	R: fxd comp 68 kΩ ±5% 1/4 W	01121	CB6835
R22	0683-1035			R: fxd comp 10 kΩ ±5% 1/4 W	01121	CB1035
R23	0683-2025		2	R: fxd comp 2000 Ω ±5% 1/4 W	01121	CB2025
R24	0683-3325		1	R: fxd comp 3300 Ω ±5% 1/4 W	01121	CB3325
R25	0683-8225		1	R: fxd comp 8200 Ω ±5% 1/4 W	01121	CB8225
R26	0757-0465		3	R: fxd prec met flm 100 kΩ ±1% 1/8 W	19701	MF5C T-O obd
R27	0698-5475		2	R: fxd met flm 1 MΩ ±1% 1/8 W	03888	PME 60 T-O obd
R28	2100-1771		2	R: var prec ww single-turn 200 Ω ±10% 1/2 W (Balance Adj)	75042	Type 500
R29	0683-4725		1	R: fxd comp 4700 Ω ±5% 1/4 W	01121	CB4725
R30	0698-4307		1	R: fxd prec met flm 14.3 kΩ ±1% 1/8 W	75042	CEA T-O obd
R31	0698-4478		1	R: fxd prec met flm 10.7 kΩ ±1% 1/8 W	91637	MFF-1/8 T-O obd
R32	0757-0438		1	R: fxd met flm 5110 Ω ±1% 1/8 W	75042	CEA T-O obd
R33	0757-0442		1	R: fxd prec met flm 10 kΩ ±1% 1/8 W	91637	MFF 1/8 T-O obd
R34	0683-5625			R: fxd comp 5600 Ω ±5% 1/4 W	01121	CB5625
R35	0683-3935		3	R: fxd comp 39 kΩ ±5% 1/4 W	01121	CB3935
R36	0757-0445		2	R: fxd prec met flm 13 kΩ ±1% 1/8 W	19701	MF5C T-O obd
R37	0683-2415		3	R: fxd comp 240 Ω ±5% 1/4 W	01121	CB2415
R38	0683-1335		1	R: fxd comp 13 kΩ ±5% 1/4 W	01121	CB1335
R39	0683-2415			R: fxd comp 240 Ω ±5% 1/4 W	01121	CB2415
R40	0757-0445			R: fxd prec met flm 13 kΩ ±1% 1/8 W	19701	MF5C T-O obd
R41	0683-6815		1	R: fxd comp 680 Ω ±5% 1/4 W	01121	CB6815
R42	0683-1025			R: fxd comp 1000 Ω ±5% 1/4 W	01121	CB1025
R43	0698-5475			R: fxd met flm 1 MΩ ±1% 1/8 W	03888	PME 60 T-O obd
R44, R47	0811-2399		2	R: matched set 2 fxd resistors 200.8 Ω +.025% 1800 Ω +.015%	-hp-	
R45	2100-1661		1	R: var ww 20 kΩ ±10% 1 W (.1 V DC Adj)	09145	170P
R46	0698-3499		1	R: fxd met flm 40.2 kΩ ±1% 1/8 W	75042	CEA T-O obd
R47, R44	0811-2399			R: matched set 2 fxd resistors 200.8 Ω +.025% 1800 Ω +.015%	-hp-	
A32	03461-66532			**DC OUTPUT AMP ASSY**	-hp-	
C1	0140-0216		1	C: fxd mica 120 pF ±2%	04062	RDM15F121G3C
C2 thru C5	0180-1743		4	C: fxd Ta elect 0.1 μF ±10% 35 vdcw	56289	150D104X9035A2-DYS
C6	0180-0159		1	C: fxd Ta elect 220 μF ±20% 10 vdcw	56289	150D227X0010S2

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
CR1, CR2	1901-0081			Diode: Si 50 wiv 10 ns 6 pF	01295	obd
CR3, CR4	1901-0040			Diode: breakdown 14 V ±5% 400 mW	07910	CD35748
Q1	1854-0215		1	TSTR: Si NPN 2N3904	04713	2N3904-5
Q2	1854-0042		1	TSTR: Si NPN	04713	SM1570
Q3	1853-0010		1	TSTR: Si PNP	07263	obd
R1	0683-3025		1	R: fxd comp 3000 Ω ±5% 1/4 W	01121	CB3025
R2	0683-6215		1	R: fxd comp 620 Ω ±5% 1/4 W	01121	CB6215
R3	0686-2015		2	R: fxd comp 200 Ω ±5% 1/4 W	01121	EB2015
R4, R5	0683-2205		2	R: fxd comp 22 Ω ±5% 1/4 W	01121	CB2205
R6	0683-1335		1	R: fxd comp 13 kΩ ±5% 1/4 W	01121	CB1335
R7	0686-2015			R: fxd comp 200 Ω ±5% 1/4 W	01121	EB2015
R8	0683-4715			R: fxd comp 470 Ω ±5% 1/4 W	01121	CB4715
R9	0757-0283		1	R: fxd met flm 2000 Ω ±1% 1/8 W	75042	CEA T-O obd
R10	0757-0449			R: fxd met flm 20 kΩ ±1% 1/8 W	75042	CEA T-O obd
R11, R12	0757-0435		2	R: fxd met flm 3920 Ω ±1% 1/8 W	19701	MF5C T-O obd
A33	03461-66533			**DC POWER SUPPLY ASSY**	-hp-	
C1	0160-0153		2	C: fxd my 0.001 µF ±10% 200 vdcw	56289	192P10292-PTS
C2	0150-0096			C: fxd cer 0.05 µF +80% -20% 100 vdcw	72982	845X5V-503Z
C3	0150-0012		2	C: fxd cer 10,000 pF ±20% 1000 vdcw	56289	29C214A3
C5	0180-0049			C: fxd Al elect 20 µF +75% -10% 50 vdcw	56289	30D206G050CC2-DSM
C6, C7	0160-2612		2	C: fxd poly 0.027 µF ±1% 50 vdcw	84411	Type 463 UW
C8	0160-0153			C: fxd my 0.001 µF ±10% 200 vdcw	56289	192P10292-PTS
C9	0150-0096			C: fxd cer 0.05 µF +80% -20% 100 vdcw	72982	845-X5V-503Z
C10	0150-0012			C: fxd cer 10,000 µF ±20% 1000 vdcw	56289	29C214A3
C11	0180-0101			C: fxd Ta elect 1.8 µF ±10% 35 vdcw	56289	150D185X9035B2
C13, C14	0180-0089		2	C: fxd Al elect 10 µF +50% -10% 150 vdcw	56289	30D106F150DD2-DSM
C15, C16	0160-0194		2	C: fxd my 0.015 µF ±10% 200 vdcw	56289	192P15392-PTS
C17	0160-0378		1	C: fxd mica 27 pF ±5%	04062	RDM15E270J5S
C20	0180-0049			C: fxd Al elect 20 µF +75% -10% 50 vdcw	56289	30D206G050CC2-DSM
CR3, CR4	1901-0081			Diode: Si 50 wiv 10 ns 6 pF	01295	obd
CR5	1902-0049		2	Diode: breakdown 6.19 V ±5% 400 mW	07910	CD35646
CR6	1902-3114		2	Diode: breakdown 6.19 V ±2% 400 mW	04713	SZ10939-123
CR7 thru CR10	1901-0081			Diode: Si 50 wiv 10 ns 6 pF	01295	obd
CR11	1902-0049			Diode: breakdown 6.19 V ±5% 400 mW	07910	CD35646
CR12	1902-3114			Diode: breakdown 6.19 V ±2% 400 mW	04713	SZ10939-123
CR13 thru CR16	1901-0159			Diode: 400 piv	04713	
CR17, CR18	1901-0081			Diode: Si 50 wiv 10 ns 6 pF	01295	obd
Q1	1853-0092			TSTR: Si PNP	04713	obd
Q2	1854-0022		1	TSTR: 2N2102	01295	SG1294
Q3 thru Q5	1854-0215			TSTR: Si NPN 2N3904	04713	obd
Q6	1853-0012		1	TSTR: Si PNP 2N2904A	04713	2N2904A
Q7, Q8	1853-0092			TSTR: Si PNP	04713	obd
Q9, Q10	1853-0071			TSTR: Si NPN	01295	SK1124
Q11	1854-0234		1	TSTR: Si NPN 2N3440	86684	obd

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
R1	0683-1035			R: fxd comp 10 kΩ ±5% 1/4 W	01121	CB1035
R2	0683-1225		2	R: fxd comp 1200 Ω ±5% 1/4 W	01121	CB1225
R3	0683-3335		2	R: fxd comp 33 kΩ ±5% 1/4 W	01121	CB3335
R4	0757-0198		2	R: fxd met flm 100 Ω ±1% 1/2 W	19701	MF7C T-O obd
R5	0683-4715		2	R: fxd comp 470 Ω ±5% 1/4 W	01121	CB4715
R6	0683-1235		3	R: fxd comp 12 kΩ ±5% 1/4 W	01121	CB1235
R7	0757-0383		2	R: fxd prec met flm 18.2 Ω ±1% 1/8 W	19701	MF5C T-O obd
R8	0757-0289		2	R: fxd prec met flm 13.3 kΩ ±1% 1/8 W	75042	CEA T-O obd
R9	0757-0438			R: fxd prec met flm 5110 Ω ±1% 1/8 W	75042	CEA T-O obd
R10	0683-1035			R: fxd comp 10 kΩ ±5% 1/4 W	01121	CB1035
R11	0698-3265		2	R: fxd met flm 118 kΩ ±1% 1/8 W	19701	MF5C T-O obd
R12 thru R15	0683-1035			R: fxd comp 10 kΩ ±5% 1/4 W	01121	CB1035
R16	0698-3265			R: fxd met flm 118 kΩ ±1% 1/8 W	19701	MF5C T-O obd
R17	0683-1035			R: fxd comp 10 kΩ ±5% 1/4 W	01121	CB1035
R18	2100-1760		1	R: var ww lin 5 kΩ ±10% (Chopper Freq Adj)	75042	Type 506
R20	0683-1035			R: fxd comp 10 kΩ ±5% 1/4 W	01121	CB1035
R21	0683-1225			R: fxd comp 1200 Ω ±5% 1/4 W	01121	CB1225
R22	0683-3335			R: fxd comp 33 kΩ ±5% 1/4 W	01121	CB3335
R23	0757-0198			R: fxd met flm 100 Ω ±1% 1/2 W	19701	MF7C T-O obd
R24	0683-1235			R: fxd comp 12 kΩ ±5% 1/4 W	01121	CB1235
R25	0683-4715			R: fxd comp 470 Ω ±5% 1/4 W	01121	CB4715
R26	0757-0383			R: fxd prec met flm 18.2 Ω ±1% 1/8 W	19701	MF5C T-O obd
R27	0757-0289			R: fxd prec met flm 13.3 kΩ ±1% 1/8 W	75042	CEA T-O obd
R28	0757-0438			R: fxd prec met flm 5110 Ω ±1% 1/8 W	75042	CEA T-O obd
R29, R30	0683-1055		2	R: fxd comp 1 MΩ ±5% 1/4 W	01121	CB1055
R31	0757-0852		2	R: fxd met flm 47.5 kΩ ±1% 1/2 W	75042	CEC T-O obd
R32, R33	0683-2235		2	R: fxd comp 22 kΩ ±5% 1/4 W	01121	CB2235
R34, R35	0683-3935		2	R: fxd comp 39 kΩ ±5% 1/4 W	01121	CB3935
R36, R37	0683-5145		2	R: fxd comp 510 kΩ ±5% 1/4 W	01121	CB5145
R38	0683-1235			R: fxd comp 12 kΩ ±5% 1/4 W	01121	CB1235
	1205-0033			Heat sink: semiconductor	05820	NF-207
A34	03461-66534			**OHMS MAJOR ASSY**	-hp-	
C1, C2	0160-0194		2	C: fxd cer 0.015 μF ±10% 200 vdcw	56289	192P15392-PTS
C3	0170-0055		1	C: fxd 0.1 μF ±20% 200 vdcw	56289	192P10402A
C4	0180-0228		1	C: fxd Ta elect 22 μF ±10% 15 vdcw	56289	150D226X9015B2
CR1 thru CR5	1901-0049		5	Diode: 50 piv	04713	SR13586
CR6	1902-0049		1	Diode: breakdown 6.19 V ±5% 400 mW	07910	CD35646
K10 thru K13	0490-0399		4	Relay: reed 1200 Ω	-hp-	
Q1	1854-0039			TSTR: Si NPN 2N3053	86684	2N3053
Q2, Q3	1854-0071			TSTR: Si NPN	01295	SK1124
R1	0698-6682		1	R: fxd met flm 9 Ω ±1% 1/8 W	75042	CEA T-O obd
R2	2100-1651		1	R: var ww 10 Ω ±10% 1 W (Lead-Ω Adj)	09145	170P
R3	0811-2475		1	R: fxd prec ww 5 MΩ ±0.01% 1 W	-hp-	
R4	0811-2400		2	R: set ww 920.54 kΩ	-hp-	
R5	2100-1659		1	R: var ww 5000 Ω ±10% 1 W (1 MΩ Adj)	09145	170P
R6	0811-2386		1	R: fxd prec ww 13.95 kΩ ±0.01% 1/8 W	-hp-	
R7	0811-2387		1	R: fxd prec ww 139.50 kΩ ±0.01% 1/8 W	-hp-	
R8	2100-1655		1	R: var ww 200 Ω ±10% 1 W (10 kΩ Adj)	09145	obd

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
R9	0811-2400			R: set ww 920.54 kΩ	-hp-	
R10	2100-1658		1	R: var ww 2000 Ω ±10% 1 W (100 kΩ Adj)	09145	170P
R11	0757-0159		1	R: fxd prec met flm 1000 Ω ±1% 1/2 W	75042	CEC T-O obd
R12	0811-1209		1	R: fxd ww 600 Ω ±5% 3 W	91637	CW-2B
R13	0757-0465		2	R: fxd prec met flm 100 kΩ ±1% 1/8 W	19701	MF5C T-O obd
R14	0683-7525		1	R: fxd comp 7500 Ω ±5% 1/4 W	01121	CB7525
R15	0757-0465			R: fxd prec met flm 100 kΩ ±1% 1/8 W	19701	MF5C T-O obd
R16	0811-2409			R: fxd prec ww 1020 Ω ±0.1%	01686	R344
R17	0811-2402		1	R: fxd prec ww 8 Ω ±5% 1/4 W	-hp-	
R18	0811-2404		1	R: fxd prec ww 16 Ω ±5% 1/4 W	01686	R344
R19	0811-2408		1	R: fxd prec ww 32 Ω ±2 % 1/4 W	07088	KP110
R20	0811-2410		1	R: fxd prec ww 64 Ω ±1%	01686	R344
R21	0811-2403		1	R: fxd prec ww 128 Ω ±0.4%	01686	R344
R22	0811-2405		1	R: fxd prec ww 80 kΩ ±1%	07088	KP110
R23	0757-0464		1	R: fxd prec met flm 90.9 kΩ ±1% 1/8 W	75042	CEA T-O obd
R24	2100-1661			R: var ww 20 kΩ ±10% 1 W (1 kΩ Adj)	09145	170P
R25	0757-0197		1	R: fxd prec met flm 1500 Ω ±1% 1/2 W	19701	MF7C T-O obd
	0340-0060		11	Terminal: large feed-thru teflon cloverleaf	98291	FT-E-15
	0340-0092		3	Terminal: small feed-thru teflon cloverleaf	98291	FT-E-12
A35	03461-67535			**DC/OHMS RELAY ASSY**	-hp-	
K7 thru K9	0490-0482		3	Relay: reed	-hp-	
K14 thru K17	0490-0480		4	Relay: reed	-hp-	
	1251-1119		1	Plug: 22 pin	02660	133-022-21
A36	03461-67536			**OHMS OVEN ASSY**	-hp-	
F1	2110-0069		1	Fuse: thermal	71400	
S1	0440-0006		1	Thermostat: mercury	18509	obd
A41	03461-66541			**AC POWER SUPPLY ASSY**	-hp-	
C1	0180-0149			C: fxd Al elect 65 μF +100% -10% 60 vdcw	56289	Type 30D D36978
C2, C3	0160-0155		4	C: fxd my 0.0033 μF ±10% 200 vdcw	56289	192P33292-PTS
C4	0180-0101			C: fxd Ta elect 1.8 μF ±10% 35 vdcw	56289	150D185X9035B2-DYS
C5	0180-0049			C: fxd Al elect 20 μF +75% -10% 50 vdcw	56289	30D206G050CC2-DSM
C6	0160-0153			C: fxd my 0.001 μF ±10% 200 vdcw	56289	192P10292-PTS
C7	0180-0149			C: fxd Al elect 65 μF +100% -10% 60 vdcw	56289	Type 30D D36978
C8, C9	0160-0155			C: fxd my 0.0033 μF ±10% 200 vdcw	56289	192P33292-PTS
C10	0180-0101			C: fxd Ta elect 1.8 μF ±10% 35 vdcw	56289	150D185X9035B2-DYS
C11	0160-0153			C: fxd my 0.001 μF ±10% 200 vdcw	56289	192P10292-PTS
C12	0180-0049			C: fxd Al elect 20 μF +75% -10% 50 vdcw	56289	30D206G050CC2-DSM
CR1 thru CR4	1901-0026		4	Diode: Si 200 piv	04713	SR1358-8
CR5	1902-0049		2	Diode: breakdown 6.19 V ±5% 400 mW	07910	CD35646
CR6	1902-3114		2	Diode: breakdown 6.19 V ±2% 400 mW	04713	SZ10939-123

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
CR7	1901-0081			Diode: Si 50 wiv 10 ns 6 pF	01295	obd
CR8	1902-0049			Diode: breakdown 6.19 V ±5% 400 mW	07910	CD35646
CR9	1902-3114			Diode: breakdown 6.19 V ±2% 400 mW	04713	SZ10939-123
CR10	1901-0081			Diode: Si 50 wiv 10 ns 6 pF	01295	obd
Q1	1853-0092			TSTR: Si PNP	04713	obd
Q2	1854-0022		1	TSTR: Si NPN	01295	SG1294
Q3 thru Q5	1854-0215		3	TSTR: Si NPN 2N3904	04713	obd
Q6	1853-0012		1	TSTR: Si PNP 2N2904A	04713	2N2904A
Q7, Q8	1853-0092			TSTR: Si PNP	04713	obd
R1	0683-1035			R: fxd comp 10 kΩ ±5% 1/4 W	01121	CB1035
R2	0683-1225		2	R: fxd comp 1200 Ω ±5% 1/4 W	01121	CB1225
R3	0683-3335			R: fxd comp 33 kΩ ±5% 1/4 W	01121	CB3335
R4	0757-0072		2	R: fxd met flm 49.9 Ω ±1% 1/2 W	75042	CEC T-O obd
R5	0683-4715		2	R: fxd comp 470 Ω ±5% 1/4 W	01121	CB4715
R6	0683-1235		2	R: fxd comp 12 kΩ ±5% 1/4 W	01121	CB1235
R7	0683-1805		2	R: fxd comp 18 Ω ±5% 1/4 W	01121	CB1805
R8	0757-0289		2	R: fxd prec met flm 13.3 kΩ ±1% 1/8 W	75042	CEA T-O obd
R9	0757-0438		2	R: fxd prec met flm 5110 Ω ±1% 1/8 W	75042	CEA T-O obd
R10	0683-1035			R: fxd comp 10 kΩ ±5% 1/4 W	01121	CB1035
R11	0683-1225			R: fxd comp 1200 Ω ±5% 1/4 W	01121	CB1225
R12	0683-3335			R: fxd comp 33 kΩ ±5% 1/4 W	01121	CB3335
R14	0683-4715			R: fxd comp 470 Ω ±5% 1/4 W	01121	CB4715
R15	0683-1235			R: fxd comp 12 kΩ ±5% 1/4 W	01121	CB1235
R16	0683-1805			R: fxd comp 18 Ω ±5% 1/4 W	01121	CB1805
R17	0757-0289			R: fxd prec met flm 13.3 kΩ ±1% 1/8 W	75042	CEA T-O obd
R18	0757-0438			R: fxd prec met flm 5110 Ω ±1% 1/8 W	75042	CEA T-O obd
	1205-0033			Heat sink: semiconductor	05820	NF-207
A42	03461-66542			**AC BUFFER AMP ASSY**	-hp-	
C1	0180-0291		2	C: fxd Ta elect 1.0 μF ±10% 35 vdcw	56289	150D105X9035A2-DYS
C2	0170-0055		5	C: fxd my 0.1 μF ±20% 200 vdcw	56289	192P10402-PTS
C3	0160-0938		1	C: fxd mica 1000 pF ±5%	04062	RDM15E102J1C
C4	0140-0191		1	C: fxd mica 56 pF ±5%	04062	RDM15E601J3C
C5	0160-0362			C: fxd mica 510 pF ±5%	04062	RDM15F511J3C
C7	0160-0194		3	C: fxd my 0.015 μF ±10% 200 vdcw	56289	192P15392-PTS
C8	0140-0205		1	C: fxd mica 62 pF ±5%	04062	RDM15E620J3C
C9	0140-0203		1	C: fxd mica 30 pF ±5%	000LM	obd
C10, C11	0170-0055			C: fxd my 0.1 μF ±20% 200 vdcw	56289	192P10402-PTS
C12, C13	0160-0194			C: fxd my 0.015 μF ±10% 200 vdcw	56289	192P15392-PTS
C14	0170-0055			C: fxd my 0.1 μF ±20% 200 vdcw	56289	192P10402-PTS
C16	0180-0291			C: fxd Ta elect 1.0 μF ±10% 35 vdcw	56289	150D105X9035A2-DYS
C17	0170-0055			C: fxd my 0.1 μF ±20% 200 vdcw	56289	192P10402-PTS
CR3, CR4	1901-0047		4	Diode: 20 wiv 1 pF 10 ns	93332	D3738
CR5, CR6	1902-3150		2	Diode: breakdown 9.09 V ±2% 400 mW	04713	SZ10939-171
CR7, CR8	1901-0047			Diode: 20 wiv 1 pF 10 ns	93332	D3738
CR9, CR10	1901-0156		2	Diode: Si 50 mA at +1 V 20 wiv	01281	PS5553
CR11	1902-0064		1	Diode: breakdown 7.50 V ±5% 400 mW	07910	CD35670
CR12, CR13	1901-0081			Diode: Si 50 wiv 10 ns 6 pF	01295	obd

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
Q1	1855-0074		1	TSTR: field effect	000LP	S-1542
Q2, Q3	1853-0036		2	TSTR: Si PNP 2N3906	04713	2N3906-5
Q4 thru Q6	1854-0215			TSTR: Si NPN 2N3904	04713	obd
Q7	1854-0042		1	TSTR: Si NPN	73445	obd
Q8	1853-0010			TSTR: Si PNP	07263	obd
Q9	1854-0071			TSTR: Si NPN 2N3391	04713	MPS-3391-5
R1	0683-1015			R: fxd comp 100 Ω ±5% 1/4 W	01121	CB1015
R2	0757-0442		2	R: fxd met flm 10 kΩ ±1% 1/8 W	75042	CEA T-O obd
R3	0683-8205		2	R: fxd comp 82 Ω ±5% 1/4 W	01121	CB8205
R4	0683-3025		1	R: fxd comp 3000 Ω ±5% 1/4 W	01121	CB3025
R5	0683-8205			R: fxd comp 82 Ω ±5% 1/4 W	01121	CB8205
R6	0683-1025			R: fxd comp 1000 Ω ±5% 1/4 W	01121	CB1025
R7	0757-0442			R: fxd met flm 10 kΩ ±1% 1/8 W	75042	CEA T-O obd
R8	0683-3915		1	R: fxd comp 390 Ω ±5% 1/4 W	01121	CB3915
R9	0683-3325		2	R: fxd comp 3300 Ω ±5% 1/4 W	01121	CB3325
R10	0683-1025			R: fxd comp 1000 Ω ±5% 1/4 W	01121	CB1025
R11	0683-1015			R: fxd comp 100 Ω ±5% 1/4 W	01121	CB1015
R12	0698-4307		1	R: fxd prec met flm 14.3 kΩ ±1% 1/8 W	75042	CEA T-O obd
R13	0698-4478			R: fxd prec met flm 10.7 kΩ ±1% 1/8 W	91637	MFF-1/8 T-O obd
R14	0757-0438		1	R: fxd met flm 5110 Ω ±1% 1/8 W	75042	CEA T-O obd
R15	0683-4725		1	R: fxd comp 4700 Ω ±5% 1/4 W	01121	CB4725
R16	2100-1769			R: var ww lin 50 Ω ±10% 1/2 W (Balance Adj)	75042	Type 500
R17	0683-1035			R: fxd comp 10 kΩ ±5% 1/4 W	01121	CB1035
R18	0698-4443		1	R: fxd met flm 4530 Ω ±1% 1/8 W	19701	MF5C T-O obd
R19	0683-3325			R: fxd comp 3300 Ω ±5% 1/4 W	01121	CB3325
R20	0683-9125		1	R: fxd comp 9100 Ω ±5% 1/4 W	01121	CB9125
R21	0683-5115		5	R: fxd comp 510 Ω ±5% 1/4 W	01121	CB5115
R22	0683-1035			R: fxd comp 10 kΩ ±5% 1/4 W	01121	CB1035
R23, R24	0683-5115			R: fxd comp 510 Ω ±5% 1/4 W	01121	CB5115
R25	0683-1035			R: fxd comp 10 kΩ ±5% 1/4 W	01121	CB1035
R26	0683-5115π			R: fxd comp 510 Ω ±5% 1/4 W	01121	CB5115
R27, R28	0683-1005		2	R: fxd comp 10 Ω ±5% 1/4 W	01121	CB1005
R29	0683-5115			R: fxd comp 510 Ω ±5% 1/4 W	01121	CB5115
	1251-1373		1	Connector (Buffer Amplifier Input)		
A43	03461-66543			**AC FINAL AMP, RECTIFIER ASSY**	-hp-	
C1	0180-1735		3	C: fxd Ta elect 0.22 μF ±10% 35 vdcw	56289	150D224X9035A2-DYS
C2, C3	0150-0012			C: fxd cer 0.01 μF ±20%	56289	29C214A3
C4	0140-0176		1	C: fxd mica 100 pF ±2%	04062	RDM15F101G3C
C5	0150-0012			C: fxd cer 0.01 μF ±20%	56289	29C214A3
C6	0180-0374		1	C: fxd Ta elect 10 μF ±10% 20 vdcw	56289	150D106X9020B2
C7	0140-0207		1	C: fxd mica 330 pF ±5%	04062	RDM15F331J5C
C8	0140-0205		1	C: fxd mica 62 pF ±5%	04062	RDM15E620J3C
C9, C10	0180-0197		3	C: fxd Ta elect 2.2 μF ±10% 20 vdcw	56289	150D225X9020A2-DYS
C11, C12	0160-0128		2	C: fxd cer 2.2 μF ±2% 25 vdcw	56289	5C15C2
C13	0180-0197			C: fxd Ta elect 2.2 μF ±10% 20 vdcw	56289	150D225X9020A2
C14	0180-1735			C: fxd Ta elect 0.22 μF ±10% 35 vdcw	56289	150D224X9035A2
C15	0180-0137		1	C: fxd Ta elect 100 μF ±20% 10 vdcw	56289	150D107X0010R2

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
C16	0180-1735			C: fxd Ta elect 0.22 μF ±10% 35 vdcw	56289	150D224X9035A2-DYS
CR1 thru CR4	1901-0047		8	Diode: 20 wiv 1 pF 10 ns	93332	D3738
CR5, CR6	1902-3094		2	Diode: breakdown 5.11 V ±2% 400 mW	04713	SZ10939-99
CR7, CR8	1901-0047			Diode: 20 wiv 1 pF 10 ns	93332	D3738
CR10, CR11	1901-0047			Diode: 20 wiv 1 pF 10 ns	93332	D3738
CR12, CR13	1901-0040			Diode: Si 30 mA at +1 V 30 piv 12 pF 2 ns	07910	CD6319
Q1	1854-0221		1	TSTR: Si NPN dual 2N4045	000LP	BD-1148
Q2, Q3	1853-0036			TSTR: Si PNP 2N3906	04713	2N3906-5
Q4	1854-0215		2	TSTR: Si NPN 2N3904	04713	obd
Q5	1853-0036			TSTR: Si PNP 2N3906	04713	2N3906-5
Q6	1854-0215			TSTR: Si NPN 2N3904	04713	obd
Q7	1853-0010		1	TSTR: Si PNP	04713	SML 4713
Q8, Q9	1854-0042		2	TSTR: Si NPN	04713	SPS 4653
Q10, Q11	1854-0071			TSTR: Si NPN 2N3391	04713	MPS 3391-5
R1	0683-1015		4	R: fxd comp 100 Ω ±5% 1/4 W	01121	CB1015
R3	0683-1015			R: fxd comp 100 Ω ±5% 1/4 W	01121	CB1015
R4	0683-6225		1	R: fxd comp 6200 Ω ±5% 1/4 W	01121	CB6225
R5	0683-1015			R: fxd comp 100 Ω ±5% 1/4 W	01121	CB1015
R6	0683-2435			R: fxd comp 24 kΩ ±5% 1/4 W	01121	CB2435
R7	0757-0280		1	R: fxd prec met flm 1000 Ω ±1% 1/8 W	19701	MF5C T-O obd
R8	0757-0468		1	R: fxd met flm 130 kΩ ±1% 1/8 W	75042	CEA T-O obd
R9	0683-2715		1	R: fxd comp 270 Ω ±5% 1/4 W	01121	CB2715
R10	0683-3615		1	R: fxd comp 360 Ω ±5% 1/4 W	01121	CB3615
R11	0683-1035		1	R: fxd comp 10 kΩ ±5% 1/4 W	01121	CB1035
R12	0698-3439		1	R: fxd met flm 178 Ω ±1% 1/8 W	75042	CEA T-O obd
R13	0683-1235		1	R: fxd comp 12 kΩ ±5% 1/4 W	01121	CB1235
R14	0683-1025		2	R: fxd comp 1000 Ω ±5% 1/4 W	01121	CB1025
R15	2100-1772		1	R: var ww lin 500 Ω ±10% 1/2 W (Balance Adj)	75042	Type 500
R16	0683-1245		1	R: fxd comp 120 kΩ ±5% 1/4 W	01121	CB1245
R17	0683-6245		1	R: fxd comp 620 kΩ ±5% 1/4 W	01121	CB6245
R18	0757-0458		2	R: fxd prec met flm 51.1 kΩ ±1% 1/8 W	75042	CEA T-O obd
R19	0683-1025			R: fxd comp 1000 Ω ±5% 1/4 W	01121	CB1025
R20	0683-2435			R: fxd comp 24 kΩ ±5% 1/4 W	01121	CB2435
R21	0757-0458			R: fxd prec met flm 51.1 kΩ ±1% 1/8 W	75042	CEA T-O obd
R22	0683-5625			R: fxd comp 5600 Ω ±5% 1/4 W	01121	CB5625
R23	0683-3315		1	R: fxd comp 330 Ω ±5% 1/4 W	01121	CB3315
R24 thru R26	0683-5625			R: fxd comp 5600 Ω ±5% 1/4 W	01121	CB5625
R27	0683-7525		1	R: fxd comp 7500 Ω ±5% 1/4 W	01121	CB7525
R28	0683-2235		1	R: fxd comp 22 kΩ ±5% 1/4 W	01121	CB2235
R29	0683-7515			R: fxd comp 750 Ω ±5% 1/4 W	01121	CB7515
R30	0683-5115		1	R: fxd comp 510 Ω ±5% 1/4 W	01121	CB5115
R31	0757-0401		1	R: fxd met flm 100 Ω ±1% 1/8 W	75042	CEA T-O obd
R32	0683-8235		1	R: fxd comp 82 kΩ ±5% 1/4 W	01121	CB8235
R33	0757-0464			R: fxd met flm 90.9 kΩ ±1% 1/8 W	75042	CEA T-O obd
R34	0757-0422		1	R: fxd prec met flm 909 Ω ±1% 1/8 W	19701	MF5C T-O obd
R35, R36	0698-6121		1	R: set fxd 100.8 Ω 900 Ω	82142	obd
R37	0757-0449			R: fxd prec met flm 20 kΩ ±1% 1/8 W	75042	CEA T-O obd
R38	0683-1015			R: fxd comp 100 Ω ±5% 1/4 W	01121	CB1015
R39	0683-1045			R: fxd comp 100 kΩ ±5% 1/4 W	01121	CB1045
R40	0683-2045		2	R: fxd comp 200 kΩ ±5% 1/4 W	01121	CB2045

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
R41	0683-1135			R: fxd comp 11 kΩ ±5% 1/4 W	01121	CB1135
R42	0683-3335		1	R: fxd comp 33 kΩ ±5% 1/4 W	01121	CB3335
R43	0683-1135			R: fxd comp 11 kΩ ±5% 1/4 W	01121	CB1135
R44	0698-3576		1	R: fxd comp 110 kΩ ±5% 1/4 W	01121	CB1145
R45	0683-1045			R: fxd comp 100 kΩ ±5% 1/4 W	01121	CB1045
R46	0683-2045			R: fxd comp 200 kΩ ±5% 1/4 W	01121	CB2045
A44	03461-66544			**AC FILTER ASSY**	-hp-	
C1	0160-2233		1	C: fxd mica 2 μF ±10% 200 vdcw	84411	HEW-45
C2	0170-0022		1	C: fxd my 0.1 μF ±20% 600 vdcw 300 vacw	84411	HEW-7
C3	0160-2034		1	C: fxd my 0.82 μF ±10% 50 vdcw	56289	148P Series
C4	0160-0164			C: fxd my 0.039 μF ±10% 200 vdcw	56289	192P39392-PTS
C5	0160-0320		1	C: fxd my 0.33 μF ±10% 100 vdcw	84411	663UW33491W
C6	0170-0043		1	C: fxd my 0.022 μF ±10% 600 vdcw	84411	HEW-93
C7	0170-0033		1	C: fxd my 0.18 μF ±2% 600 vdcw 300 vacw	56289	148P242-PYL
K4	0490-0464		1	Relay: reed	-hp-	
K5	0490-0482		1	Relay: reed	-hp-	
R1	0757-0449		1	R: fxd prec met flm 20 kΩ ±1% 1/8 W	75042	CEA T-O obd
R2, R3	0698-4509		2	R: fxd met flm 80.6 kΩ ±1% 1/8 W	75042	CEA T-O obd
R4 thru R6	0683-1015			R: fxd comp 100 Ω ±5% 1/4 W	01121	CB1015
R7	0757-0190		1	R: fxd met flm 20 kΩ ±1% 1/2 W	75042	CEC T-O obd
	1251-0324		3	Connector (filter output)	000LX	69026-1064
	0340-0127		1	Terminal: standoff		
A45	03461-66545			**AC ATTENUATOR ASSY**	-hp-	
A45-1	03461-66545		1	Subassembly (Final Attenuator)	-hp-	
C1	0160-2965		1	C: fxd my 0.068 μF ±10% 1200 vdcw	01281	HEW-106
C2, C3, C7, C10	0160-2941		4	C: set 20 pF, 18 pF, 1970 pF		
C6	0121-0116		1	C: var 2.2 pF - 21.9 pF (100 V - 20 kHz Adj)	74970	189-508-5
C7, C2, C3, C10	0160-2941			C: set		
C8	0121-0131		1	C: var 1.2 pF - 4.2 pF (10 V - 20 kHz Adj)	74970	189-508-5
C10, C2, C3 C7	0160-2941			C: set		
C11, C12	0121-0105		1	C: var (1 V - 100 kHz Adj 10 V - 100 kHz Adj)		
C13	0140-0203		1	C: fxd mica 30 pF ±5%	04062	RDM15F300J5C
K2				Relay		
	9100-1384		1	Coil: electromagnetic	-hp-	
	0490-0401		2	Switch: reed	95348	MR-456
K3				Relay		
	9100-0362		1	Coil: electromagnetic	-hp-	
	0490-0401			Switch: reed	95348	MR-456
R1, R2, R4	0698-6119		1	R: matched set fxd 25.2 kΩ, 2.5 MΩ, 5 MΩ	82142	obd
R3	2100-1771		1	R: var prec ww single-turn 200 Ω ±10% 1/2 W (100 V - 200 Hz Adj)	75042	Type 500
R4, R1, R2	0698-6119			R: matched set fxd	82142	obd
R5, R6, R8	0698-6125		1	R: matched set fxd 2.35 kΩ, 5.54 kΩ, 50 kΩ	82142	obd

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
R7	2100-1653		1	R: var ww 50 Ω ±10% 1 W (1 V - 200 Hz Adj)	09145	170P
R8, R5, R6	0698-6125			R: matched set fxd	82142	obd
R9	2100-1481		1	R: var ww lin 50 Ω ±5% 3/4 W (10 V - 200 Hz Adj)	12697	76JA3CM32464
R10	0683-2415		1	R: fxd comp 240 Ω ±5% 1/4 W	01121	CB2415
R11	0683-5115			R: fxd comp 510 Ω ±5% 1/4 W (Bias Adj)	01121	CB5115
R12	0683-1025			R: fxd comp 1000 Ω ±5% 1/4 W	01121	CB1025
R13	0683-2025			R: fxd comp 2000 Ω ±5% 1/4 W	01121	CB2025
R14	0683-1055		1	R: fxd comp 1 MΩ ±5% 1/4 W	01121	CB1055
R15	0698-4485		1	R: fxd met flm 23.2 kΩ ±1% 1/8 W	75042	CEA T-O obd
R16	0698-3162		1	R: fxd met flm 46.4 kΩ ±1% 1/8 W	75042	CEA T-O obd
	03461-00404		1	Cover	-hp-	
				NOTE		
				See Figure 7-3 for Part Nos of A45 terminals.		
A46	03461-26546			**AC JUMPER ASSY (OPTION 02)**	-hp-	
A50				**CHASSIS**		
				Assembly interconnection boards		
	03461-66514			AC	-hp-	
	03461-66513			DC and Ohms	-hp-	
	03461-66512			Inguard Logic	-hp-	
	03461-66511			Outguard Logic	-hp-	
				Note: Part Nos. include all parts mounted on boards		
				Binding-post parts		
	5060-5903		1	Coupler: Low-to-Guard	-hp-	
	0340-0159		7	Front insulator	-hp-	
	5080-1278		3	Post: black	-hp-	
	5080-1277		4	Post: red	-hp-	
	0340-0100		7	Rear insulator	-hp-	
	0361-24701		7	Support		
C1	0160-3003			C: fxd cer 20 pF ±5% 1200 vdcw	72982	808 C0G0 200 J
C2, C3	0180-0149			C: fxd Al elect 65 μF +100% -10% 60 vdcw	56289	Type 30D D36978
CR1 thru CR5	1901-0081			Diode: Si 50 wiv 10 ns 6 pF	01295	obd
CR6	1902-3205			Diode: breakdown 15 V ±5% 400 mW		
CR7 thru CR10	1901-0158			Diode: 200 piv	04713	SR1358-3
	2100-0008			Fuse: 115 V slow-blow		
	2100-0018			Fuse: 230 V slow-blow		
	1400-0084			Fuse holder	75915	342014
	5040-4528			Guide (for assemblies)	-hp-	
J1A, J2A, J3B J4A, J21A, J22, J23A, J31B, J34B, J45	1251-1557			Jack: 10 pin	07233	

Table 6-1. Replaceable Parts (Cont'd)

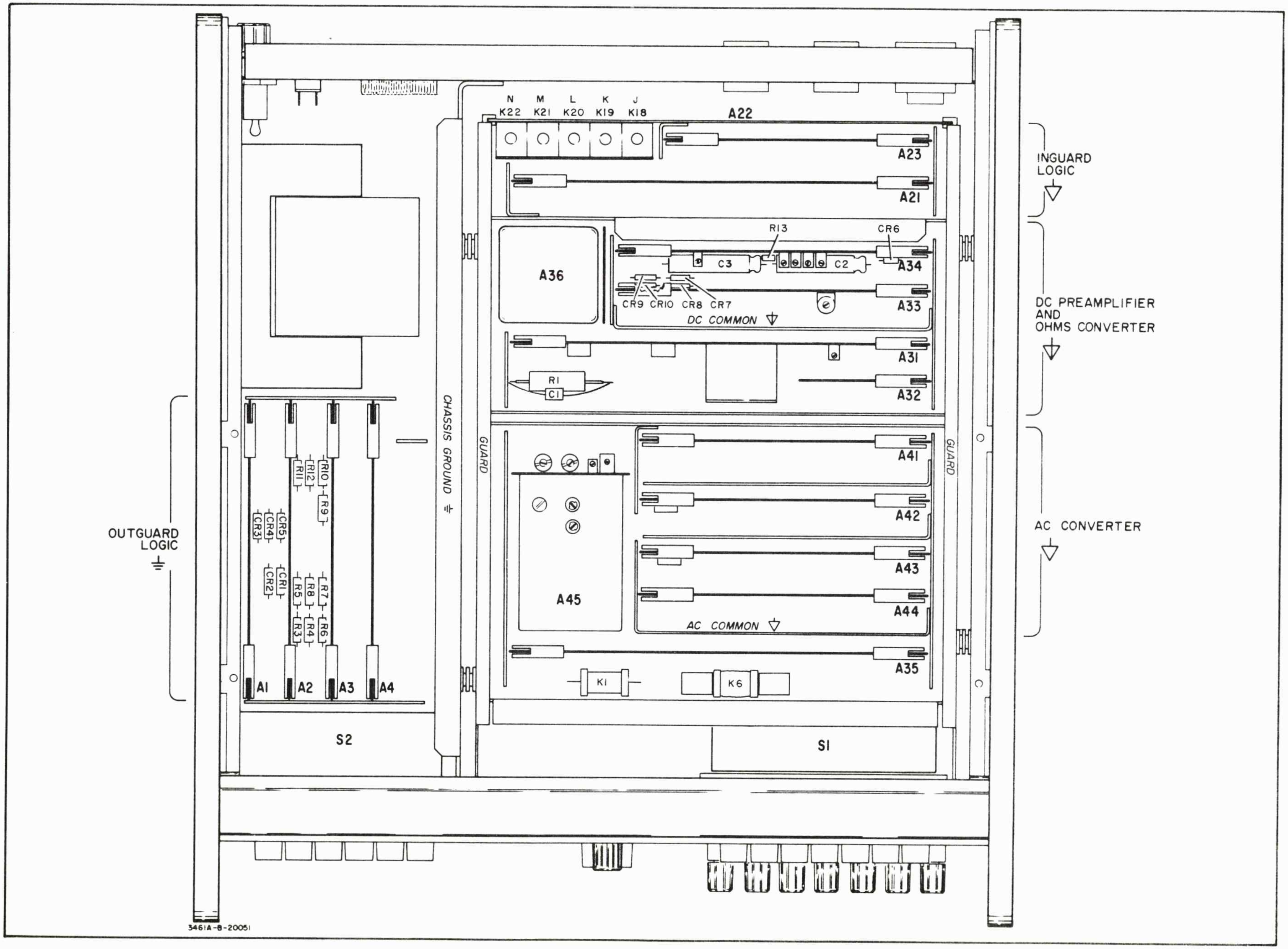
REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
J1B, J2B, J3A, J4B, J21B, J23B, J31A, J32, J33, J34A, J35, J41, J42, J43, J44	1251-1558			Jack: 15 pin	07233	63-719-15
J36	1251-1889			Jack (Oven) 15 pin	02660	64-15
J51	1251-1232			Jack (Ohms Input)	04919	A-1370
J52, J53	1251-0349			Jack (Volts Input, Output)	04919	7282
J54, J55	1251-0085			Jack (Remote Control, Interface Logic)		
J56	1251-0148			Jack (Power)		
	1251-0324			Jack (on K1)	000LX	69026-1064
DS1	2140-0219			Lamp: incandescent 28 V 40 mA ("NO")	24446	1762D
				Labels		
	7120-0861			AC/OHMS CONVERTER · DC PREAMPLIFIER	91345	Scotchcal 9650
	7120-0862			AC CONVERTER	91345	Scotchcal 9650
	7120-0863			DC PREAMPLIFIER	91345	Scotchcal 9650
	7120-0864			AC CONVERTER · DC PREAMPLIFIER	91345	Scotchcal 9650
	7120-0865			OHMS CONVERTER · DC PREAMPLIFIER	91345	Scotchcal 9650
	5000-3263			DC	-hp-	
	5000-3264			OHMS	-hp-	
	5000-3265			.1/1 K	-hp-	
	5000-3266			1/10 K	-hp-	
	5000-3267			10/100 K	-hp-	
	5000-3268			100/1 M	-hp-	
	5000-3269			1000/10 M	-hp-	
	5000-3341			ACN	-hp-	
	5000-3342			ACF	-hp-	
	5000-3343			BYPASS	-hp-	
	5000-0333			REMOTE	-hp-	
	5000-0328			AUTO	-hp-	
				Metal parts		
	5060-0761			Bottom cover	-hp-	
	03461-04102			Bottom guard	-hp-	
	5060-0767			Foot	-hp-	
	03461-00201			Front panel	-hp-	
	03461-04301			Front trim	-hp-	
	03461-01207			Oven bracket	-hp-	
	03461-00202			Rear panel	-hp-	
	5060-0730			Side frame	-hp-	
	5000-0731			Side panel	-hp-	
	5000-0050			Side trim: 7/8" wide	-hp-	

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
	1490-0030			Tilt stand	91260	obd
	5060-0749			Top cover	-hp-	
	03461-04101			Top guard	-hp-	
	03461-01211			ZERO bracket	-hp-	
	03461-23201			ZERO coupler shaft	-hp-	
				"NO" Indicator parts		
	03461-24301			Decal	-hp-	
	03461-04103			Diffusor plate	-hp-	
	2140-0219			Lamp: incandescent 28 V 40 mA	24446	1762D
	03461-24702			Lampholder	-hp-	
	03460-1472			Terminals	-hp-	
	03461-24601			Window	-hp-	
	1251-0131			Receptacle (AC Filter output)	000LX	69026-1165 (red)
K1				Relay: reed		
	9100-1356			Coil	-hp-	
	0490-0444			Switch: reed	95348	MR338
	0340-0128			Terminal: standoff teflon	98291	ST-1500 SL
	1251-0324			Jack	000LX	69026-1064
K6	0490-0487			Relay: reed	-hp-	
R1	0811-2385			R: fxd prec ww 95.2 kΩ ±3% 25 W (Preamp input)	91637	RH-25
R2	2100-2414			R: var prec ww lin 10-turn 5000 Ω ±5% 2 W (ZERO	75042	Series 7300
R3 thru R12	0686-3925			R: fxd comp 3900 Ω ±5% 1/2 W (Counter load)	01121	CB3925
R13	0683-2745			R: fxd comp 270 kΩ ±5% 1/4 W (Preamp. P.S.)	01121	CB2745
R14	0683-3335			R: fxd comp 33 kΩ ±5% 1/4 W (Power switch)	01121	CB3335
				Spacers		
	5020-5318			On top and bottom Guards: insulating	-hp-	
	5040-4503			On assembly interconnection boards, and between A31 and sheet metal: insulating	-hp-	
	5040-0639			Between frame and side Guards: insulating	-hp-	
	03460-24701			Between frame and side Guard: metal hex	-hp-	
	5040-4527			Between frame and DC and AC sheet metal: insulating	-hp-	
S1	3101-0816			Switch: pushbutton (RANGE)	76854	Type 130
S2	3101-0815			Switch: pushbutton (FUNCTION)	76854	Type 130
S3	3100-1739			Switch: rotary (FRONT/REAR)	76854	obd
S4	3101-0100			Switch: pushbutton (ON/OFF)	87034	54-61681-26
S5	3101-0033			Switch: slide (115 V/230 V)	82389	11A-1009
	0340-0128			Terminal: K1 standoff teflon	98291	ST-1500 SL
T1	9100-1371			Transformer: power supply	-hp-	

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.		TQ	DESCRIPTION	MFR.	MFR. PART NO.
				ZERO Adj parts		
R2	2100-2414			R: var prec ww lin 10-turn 5000 Ω ± 5% 2 W	75042	Series 7300
	03461-01211			Bracket	-hp-	
	03461-23201			Coupler shaft	-hp-	
				MISCELLANEOUS		
				Assembly extenders		
	5060-6032			Extender: 20 pin	-hp-	
	5060-0630			Extender: 22 pin	-hp-	
	5060-6033			Extender: 30 pin	-hp-	
				Cables		
	11092A			Interface Logic	-hp-	
	11090A			Ohms Input	-hp-	
	11091A			Output	-hp-	
	8120-0078			Power	70903	KH-4147
	11093A			Remote Control	-hp-	
	11065A			Volts Input	-hp-	
	03461-90000			Manual: Operating and Service	-hp-	



A50 Component Location

SECTION VII

CIRCUIT DIAGRAMS

7-1. This section contains block diagrams, schematics, and parts location drawings. The Analog Block Diagram, Figure 7-5, represents the circuitry involved in the actual ac and ohms conversion and dc preamplification processes; the Logic Block Diagram, Figure 7-11, represents the circuitry responsible for the range and function selection and 3460B control. A close corelation exists between the block diagrams and schematics to aid in understanding.

7-2.

Resistor and capacitor values are in ohms and microfarads unless otherwise denoted.

Relays are numbered sequentially throughout the instrument; all other components according to respective assemblies. Some component numbers may be missing.

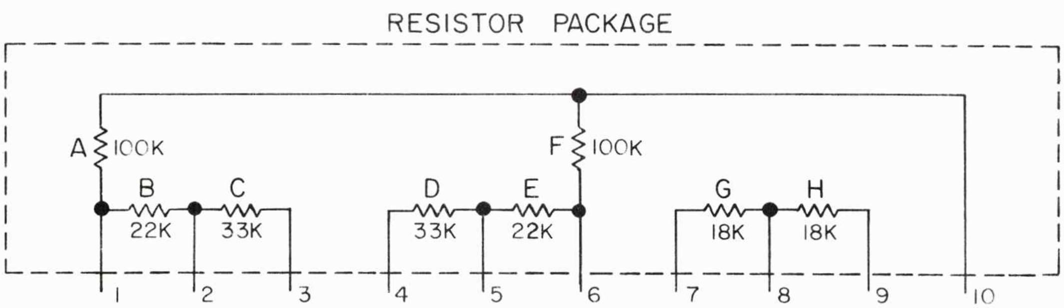
Relays are shown in deenergized position.

Voltages indicated on circuit elements are dc.

Arrows on schematics indicate signal flow.

Circuits are placed on schematics according to function, not according to physical layout on assemblies.

Some resistors in the logic circuitry are packaged as shown:



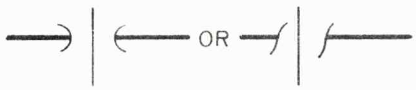
7-3. SYMBOLS.

Removable assembly

Signal feedback

A heavy line indicates signal path.

There are three separate circuit ground systems: Outguard Logic (outer chassis), AC Converter and Inguard Logic, and DC Preamplifier. Numbers adjacent to symbols are the connecting assembly pins.



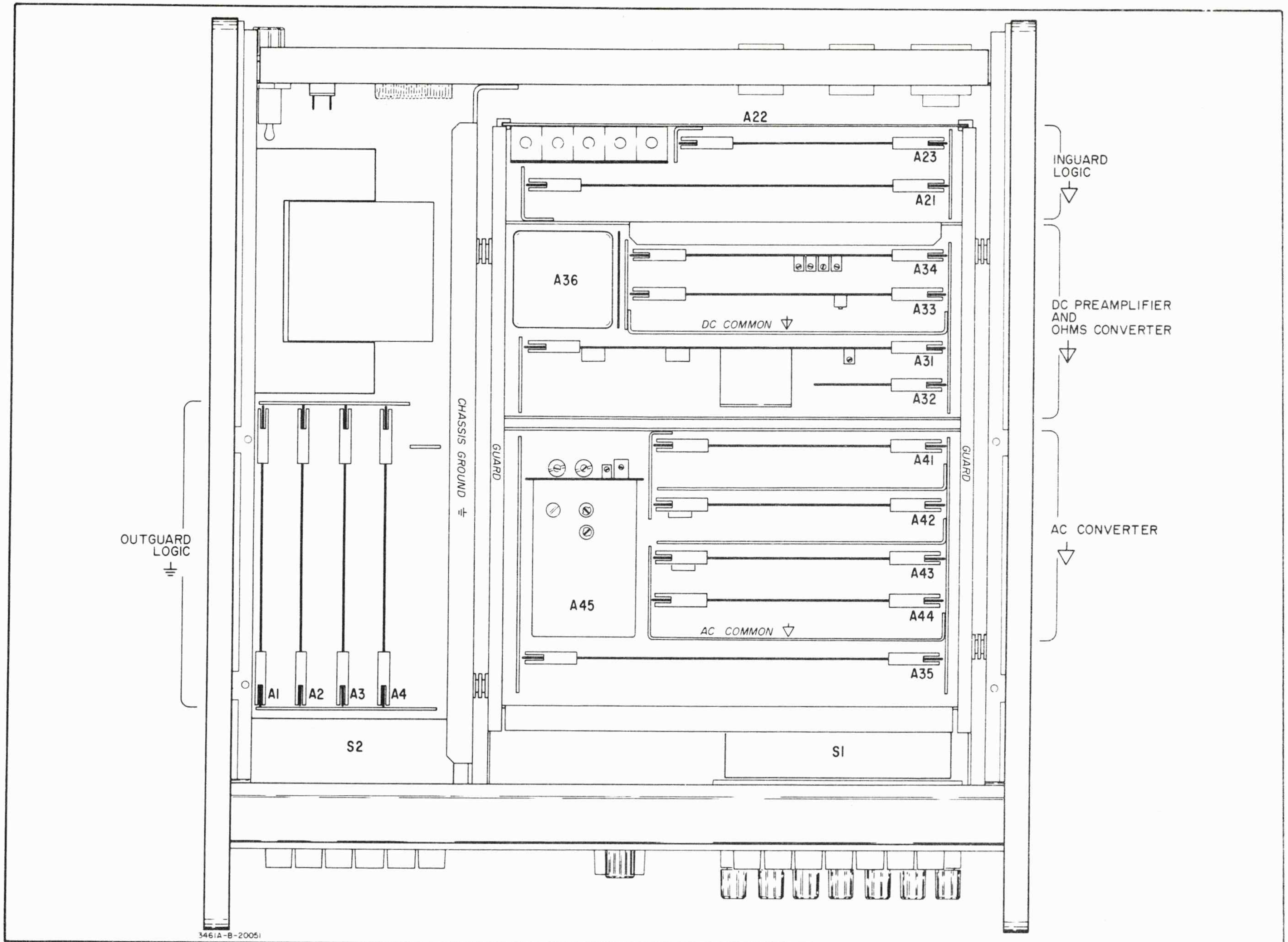
Some lines are drawn across assemblies for convenience although they do not connect to the assemblies.

\XXX/ Wire color. First number is base color; second is wide strip; third is narrow strip. Code is same as resistor code: \918/ = white, red, yellow.

Adjustment point

7-4. REMOVABLE ASSEMBLIES.

A1	Outguard Logic	Outguard Driver	03461-66501
A2		Auto Inhibit, Range Select	03461-66502
A3		Range and Function Counters	03461-66503
A4		Auto Buffer, "NO" Driver, Outguard Logic Power Supply	03461-66504
A21	Inguard Logic	AC/Bypass Driver, Inguard Logic Power Supply	03461-66521
A22		Through-Guard Relays	03461-66522
A23		DC/Ohms Driver	03461-66523
A31	DC Preamp and Ohms Converter	DC Major Assy	03461-66531
A32		DC Output Amplifier	03461-66532
A33		DC Power Supply	03461-66533
A34		Ohms Major Assy	03461-66534
A35		DC/Ohms Relays	03461-67535
A36		Ohms Oven Assy	03461-67536
A41	AC Converter	AC Power Supply	03461-66541
A42		AC Buffer Amplifier	03461-66542
A43		AC Final Amplifier, Rectifier	03461-66543
A44		AC Filter	03461-66544
A45		AC Attenuator	03461-66545
A46		Jumper Assy (Option 02)	03461-66546
A50		Chassis	



Assembly Location

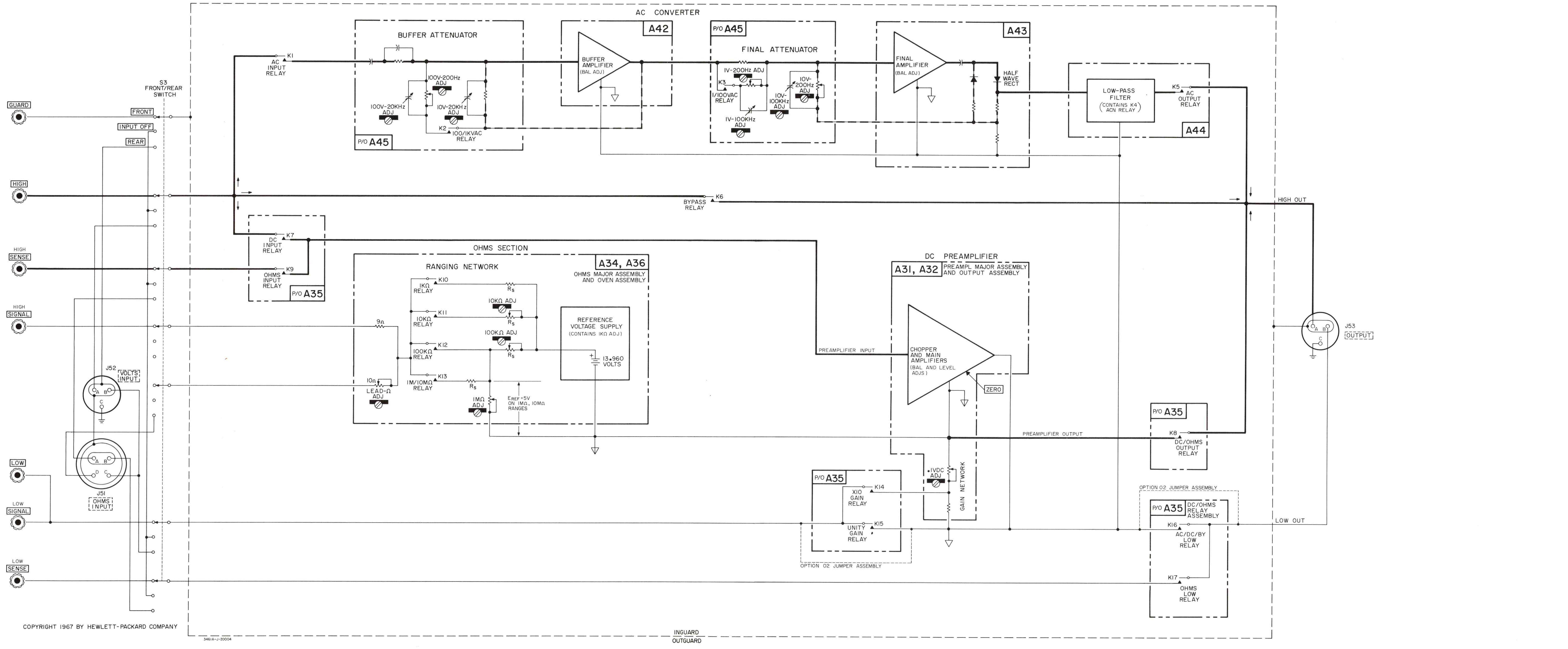
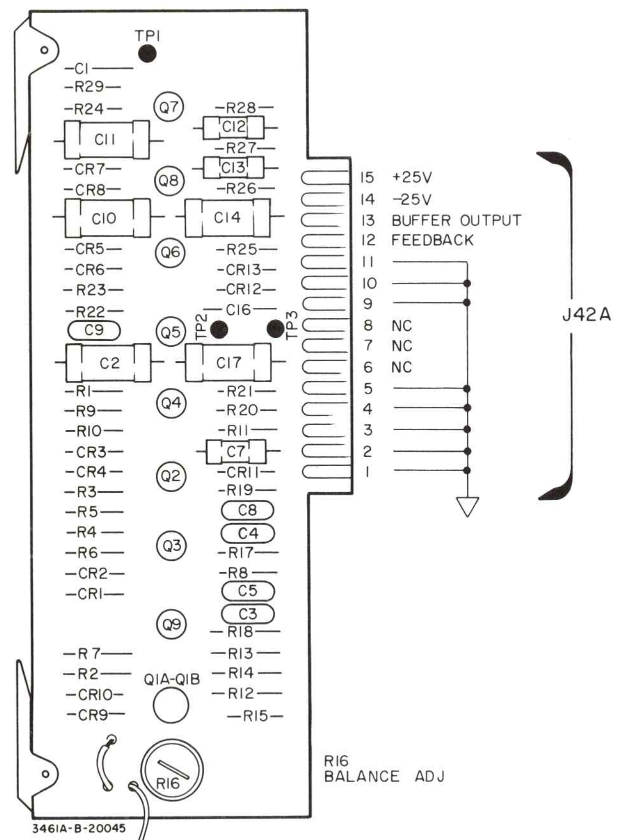
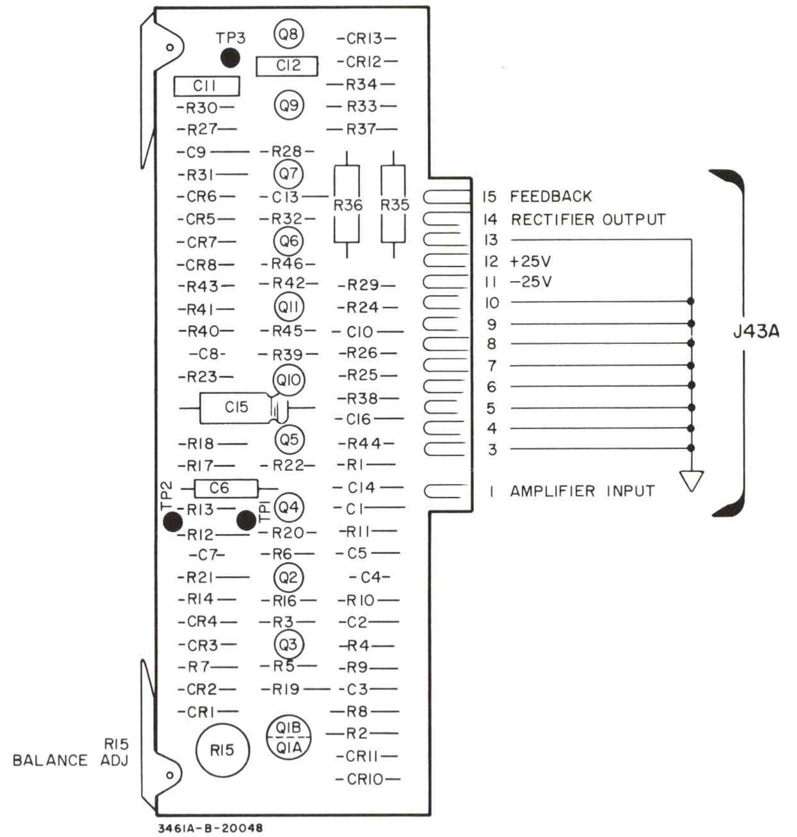


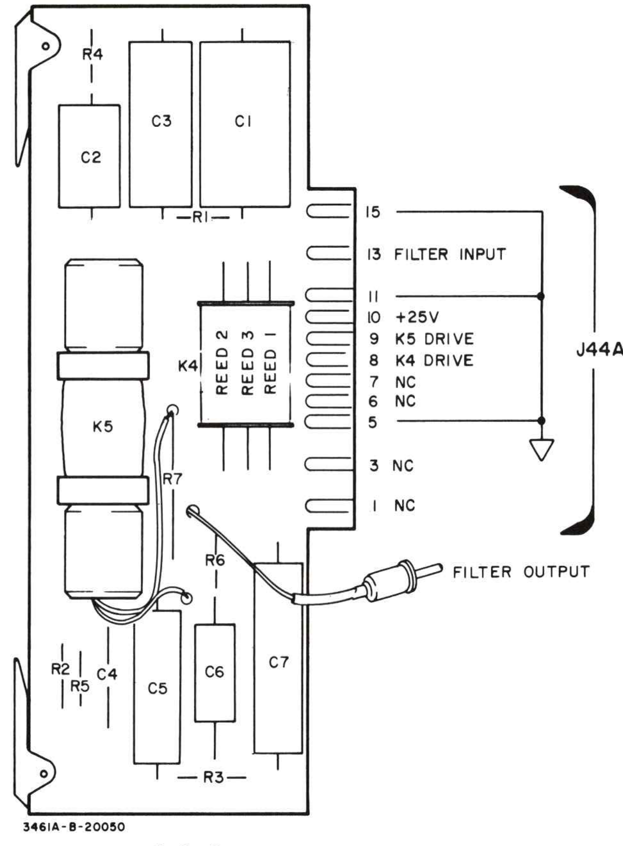
Figure 7-2. ANALOG BLOCK DIAGRAM



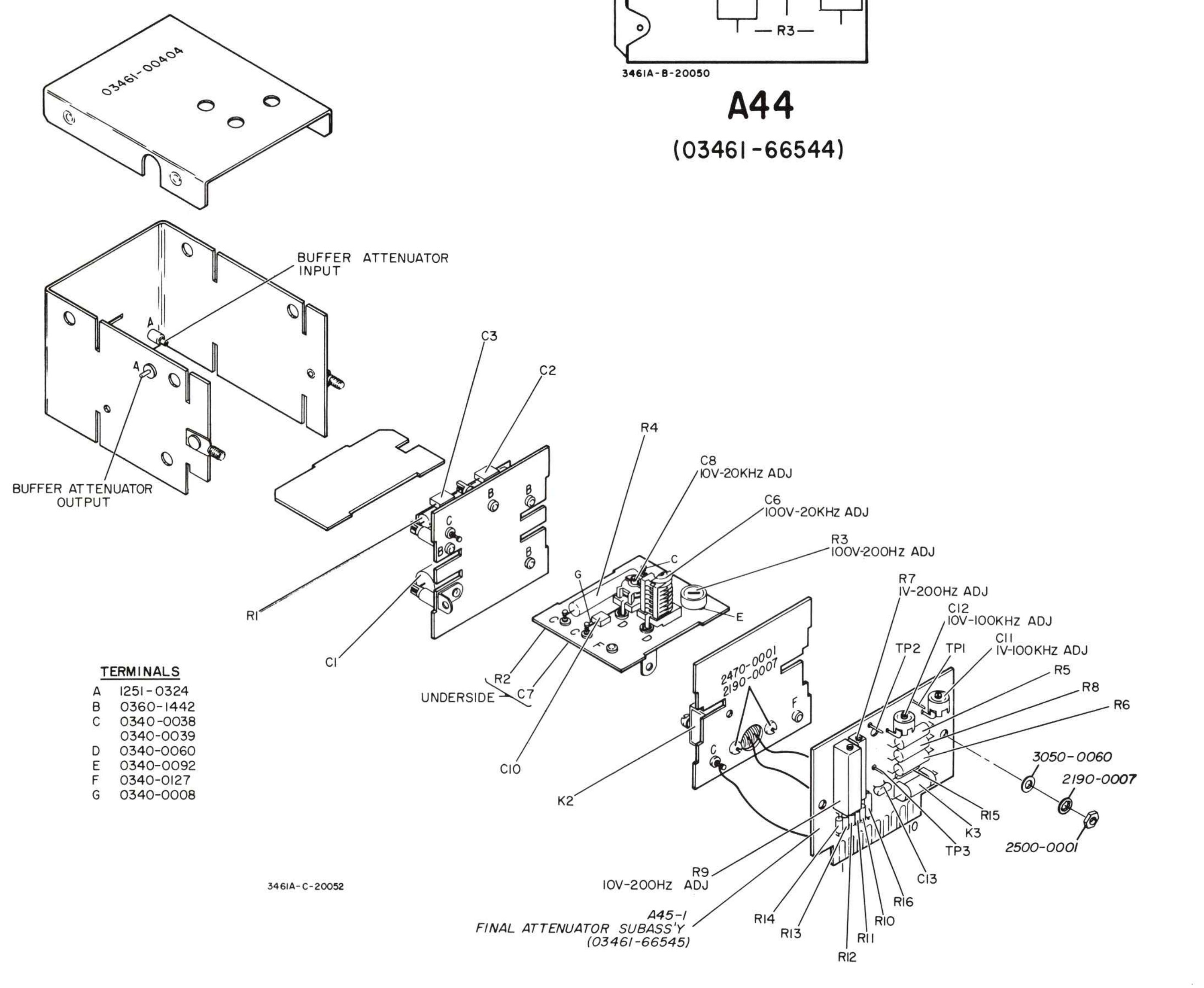
A42
(03461-66542)



A43
(03461-66504)



A44
(03461-66544)



TERMINALS

A 1251-0324
B 0360-1442
C 0340-0038
 0340-0039
D 0340-0060
E 0340-0092
F 0340-0127
G 0340-0008

A45

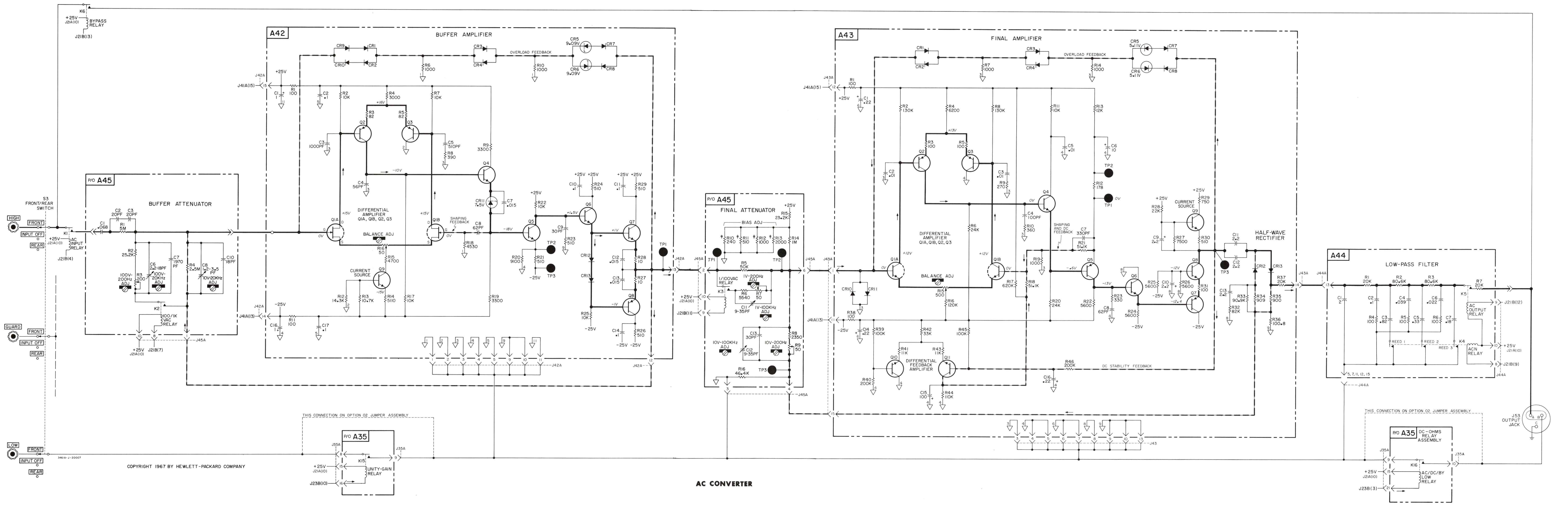
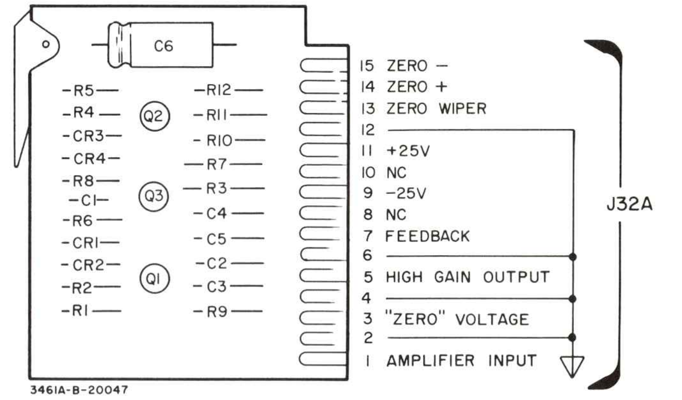
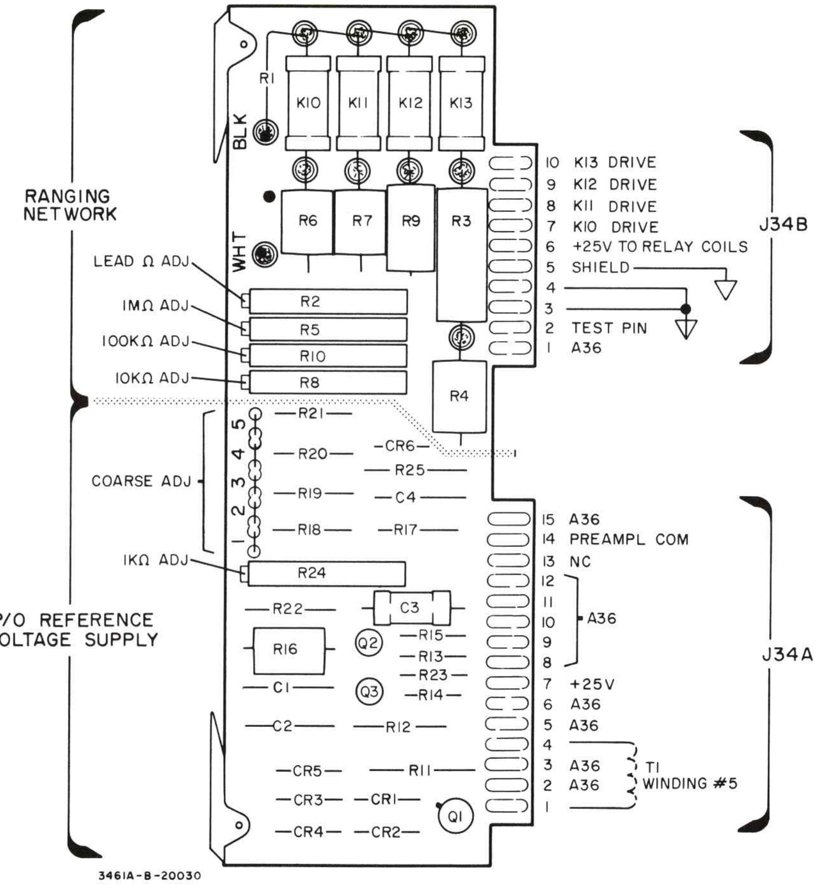


Figure 7-3. AC CONVERTER (A35, A42, A43, A44, A45)

A31
(03461-66531)

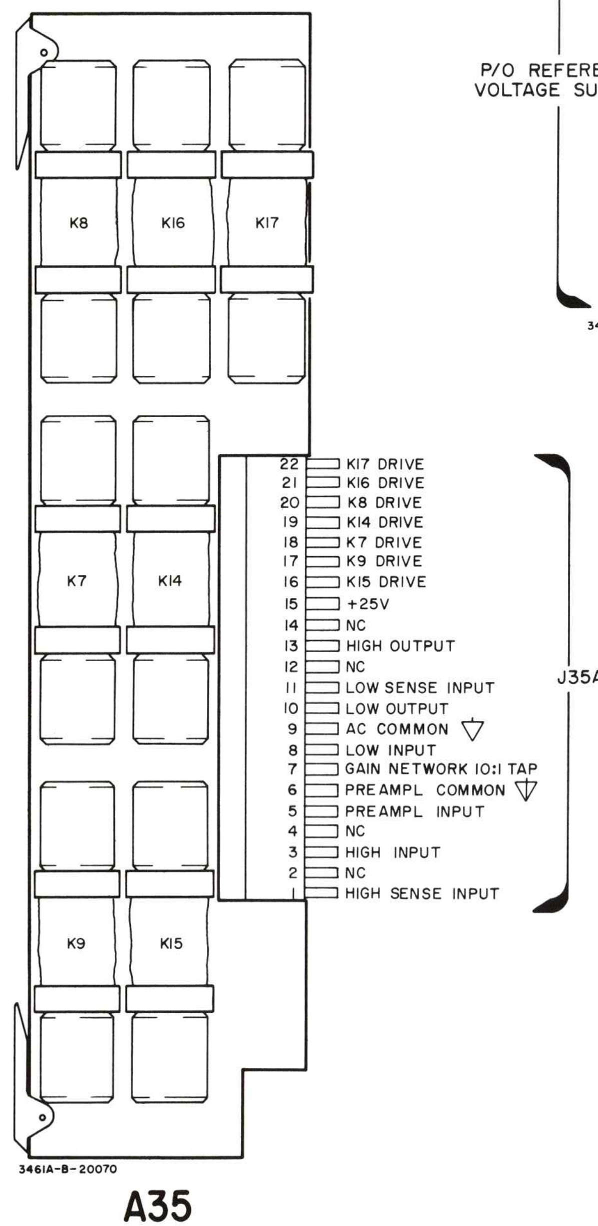


A32
(03461-66532)



A34

(03461-66534)



A35

(03461-67535)

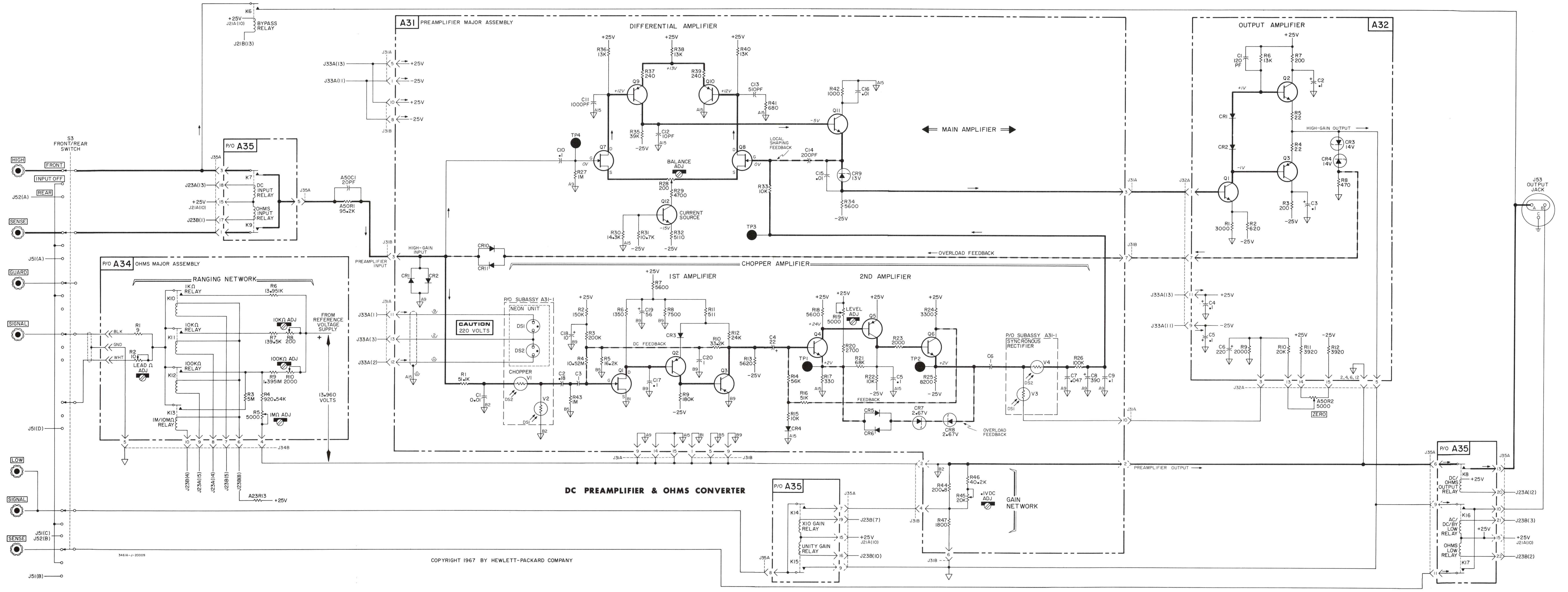
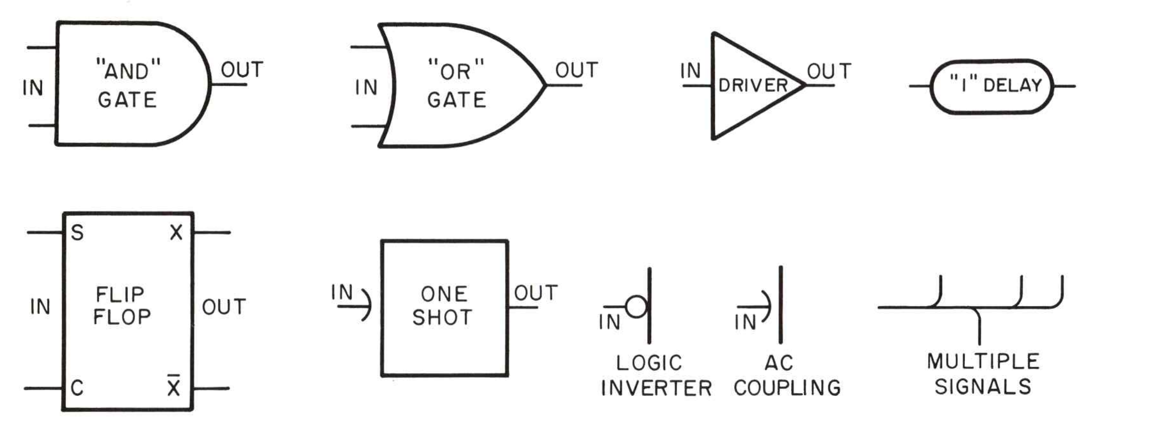


Figure 7-4. DC PREAMPLIFIER, OHMS CONVERTER (A31, A32, A34, A35)

NOTES

1. Removable assemblies are denoted by ——— - - ——— - - ——— Range and Function Counters are on the same Assembly, A3. A4 and A21 contain a power supply in addition to logic.
2. Arrow on or parallel to lines indicate signal direction.
3. The Range and Function Switch hookup is only approximated on the Logic Block Diagram. See Counter Schematic, Figure 7-6, for actual hookup.
4. Some lines run directly from the Remote Control Jack to the Interface Logic Jack to program the 3460B.
5. "True" or "1" logic level is a short to circuit common or a low voltage; "false" or "0" is an open circuit or a relatively high voltage. Either logic level may be "active" in the sense that it causes a gate or driver output to become "true."
6. A bar above a signal name indicates inverted logic levels on the line; i.e., ground = "0" and open = "1."
7. K signal inguard is denoted by ~~K~~ to relate that, unlike K, it cannot become "1" on Bypass function.
8. Both J and $\overline{J}$ lines outguard may go to the "high" level simultaneously to illuminate the "NO" Indicator.
9. AND gates have a "true" output only when all inputs are "active"; OR gates have a "true" output when any input is "active."
10. Drivers invert logic levels if a Logic Inverter symbol is shown; otherwise they pass either level without inversion.
11. Delay capacitors delay the "true" level only.
12. Flip-flops have two stable states such that the two output lines are at opposite levels. S input makes X go "true" (low), and C input makes $\overline{X}$ go "true" (low). T input alternates the outputs whichever the state.
13. The one-shot has a "true" output for only about 7 milliseconds following a "0"-to-"1" alternation of the input.
14. A Logic Inverter symbol indicates that a "false" level is the "active" input level to a gate or driver.
15. AC coupling requires that a signal must alternate levels to be "active."
16. Multiple signals, either on separate lines or on the same line, are shown bundled together to simplify the diagram.



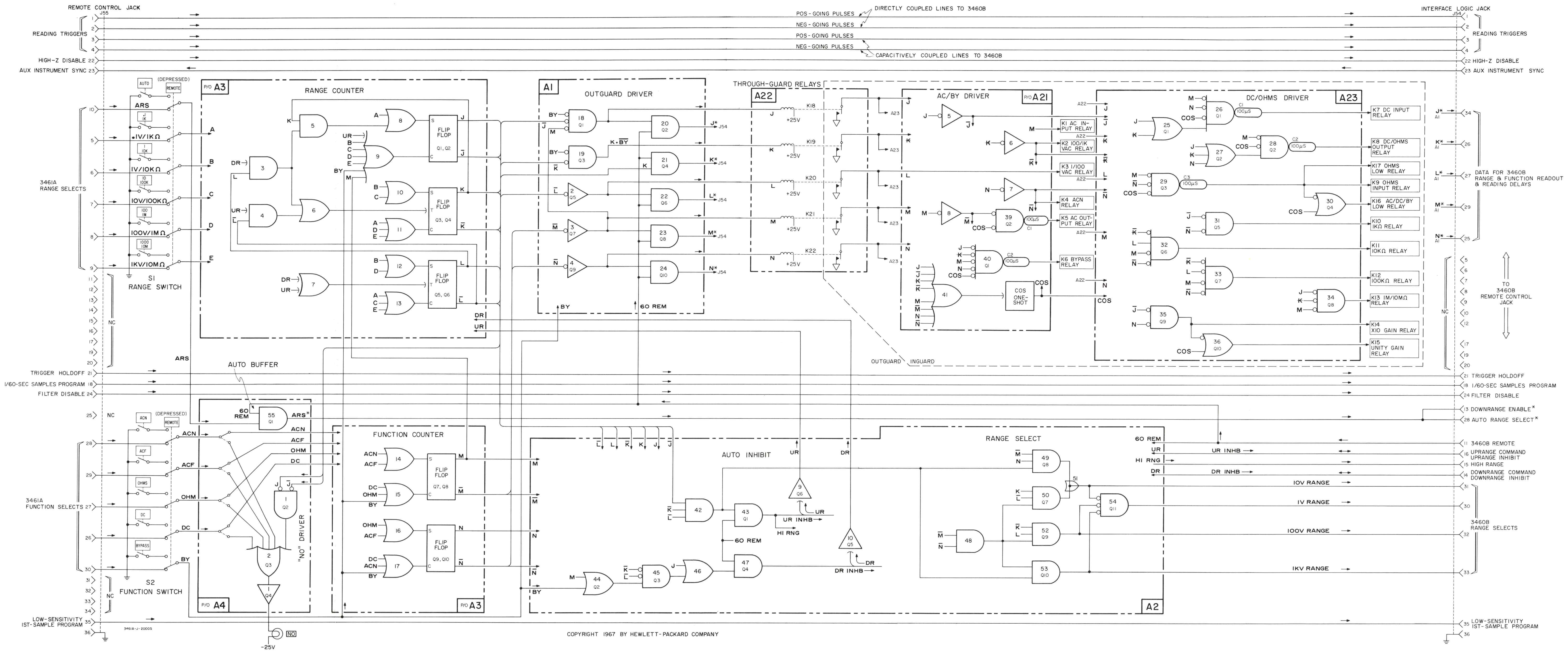
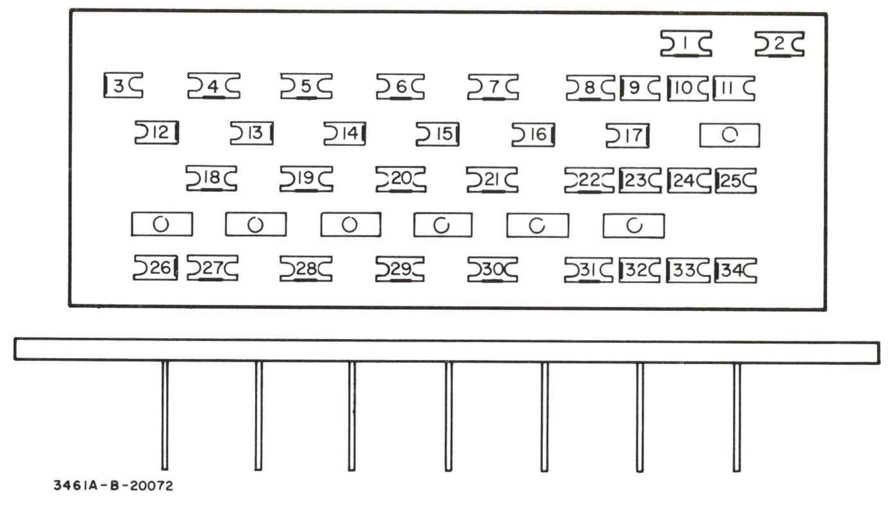
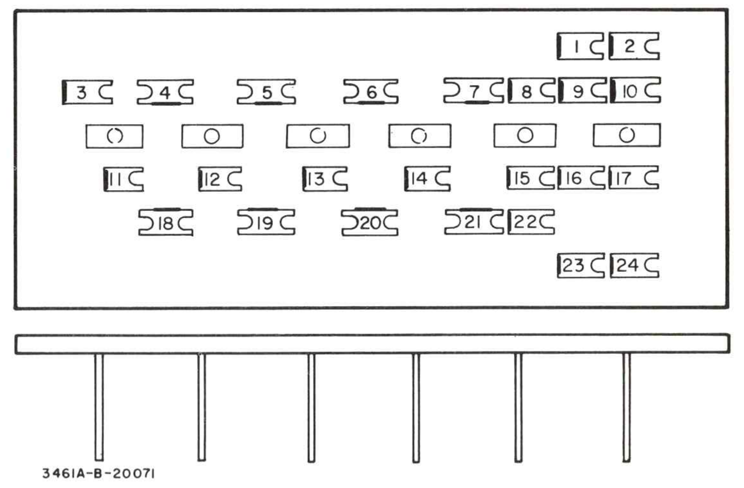


Figure 7-5. LOGIC BLOCK DIAGRAM



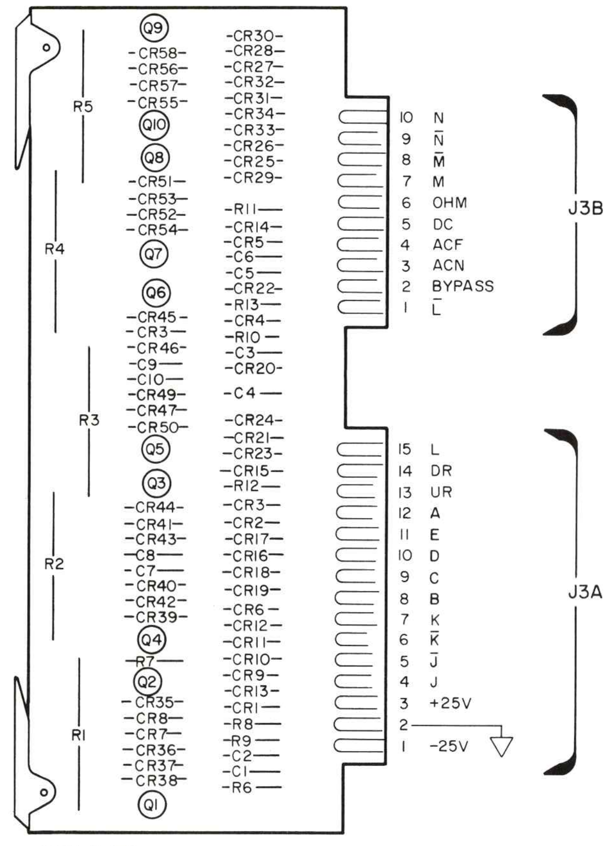
S1

RANGE SWITCH



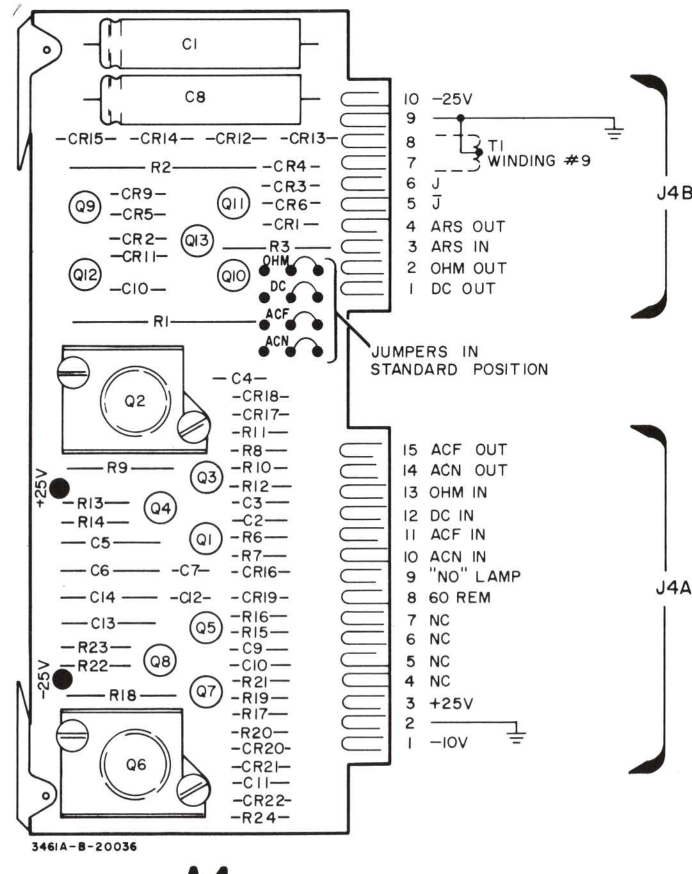
S2

FUNCTION SWITCH



A3

(03461-66503)



A4

(03461-66504)

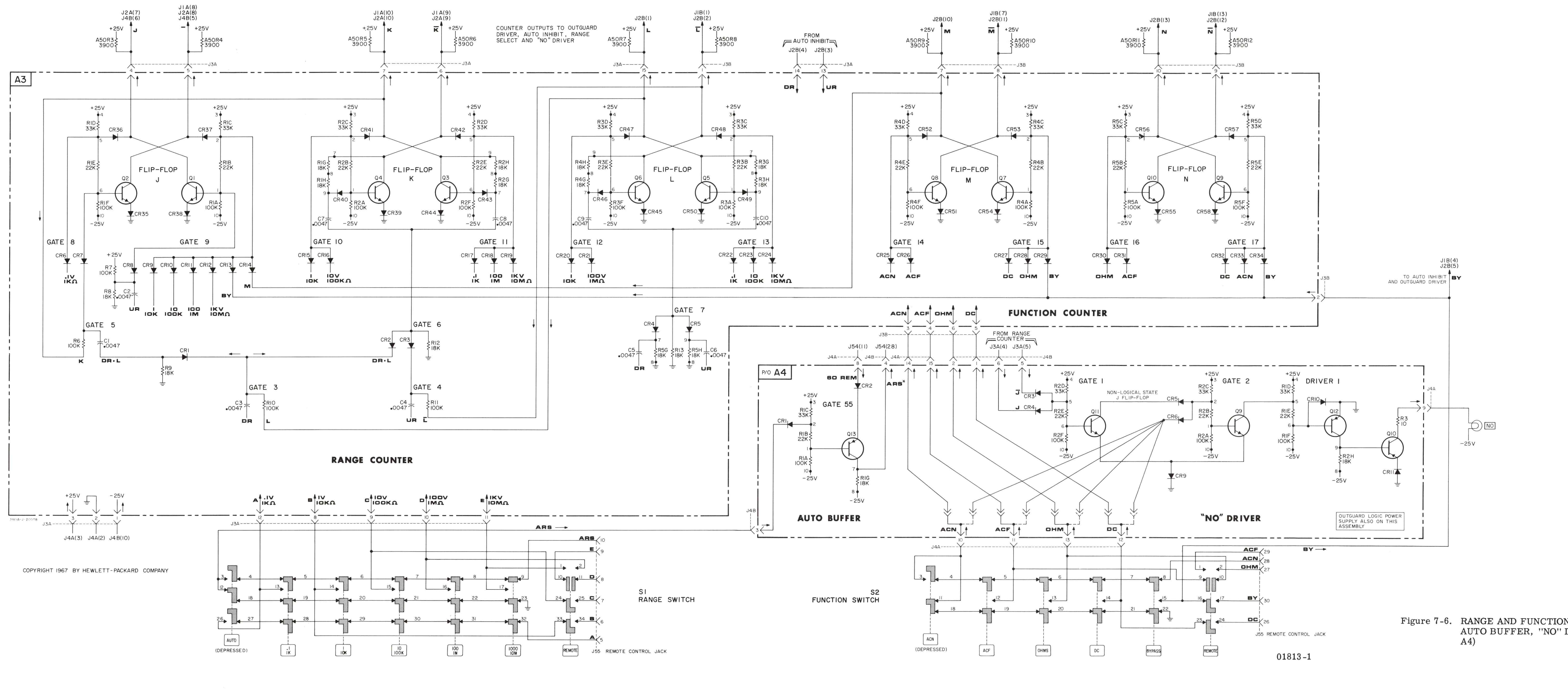
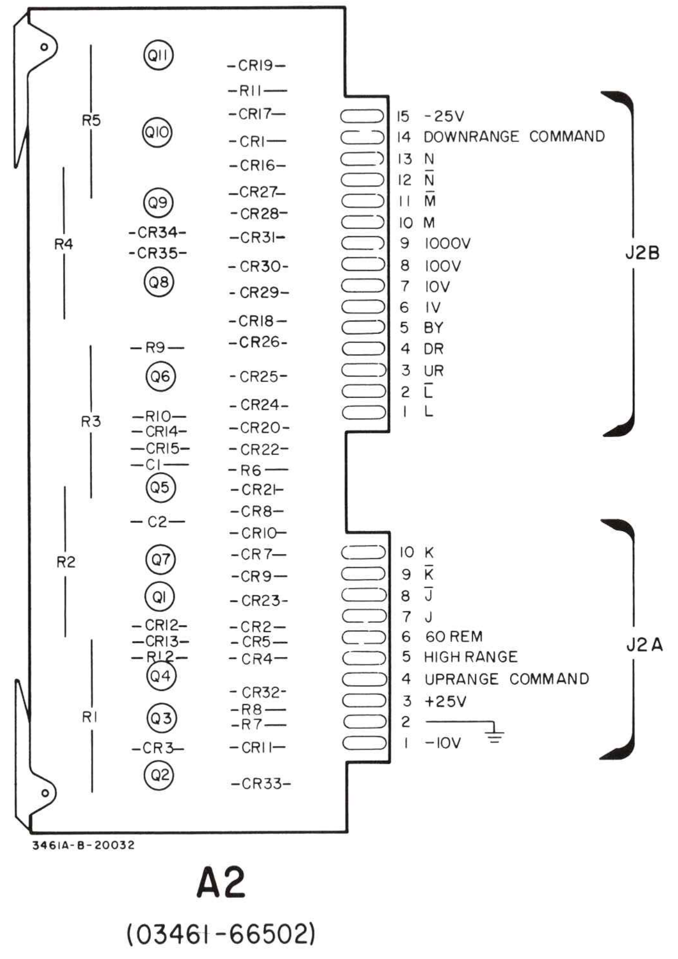


Figure 7-6. RANGE AND FUNCTION COUNTERS, AUTO BUFFER, "NO" DRIVER (A3, A4)

01813-1



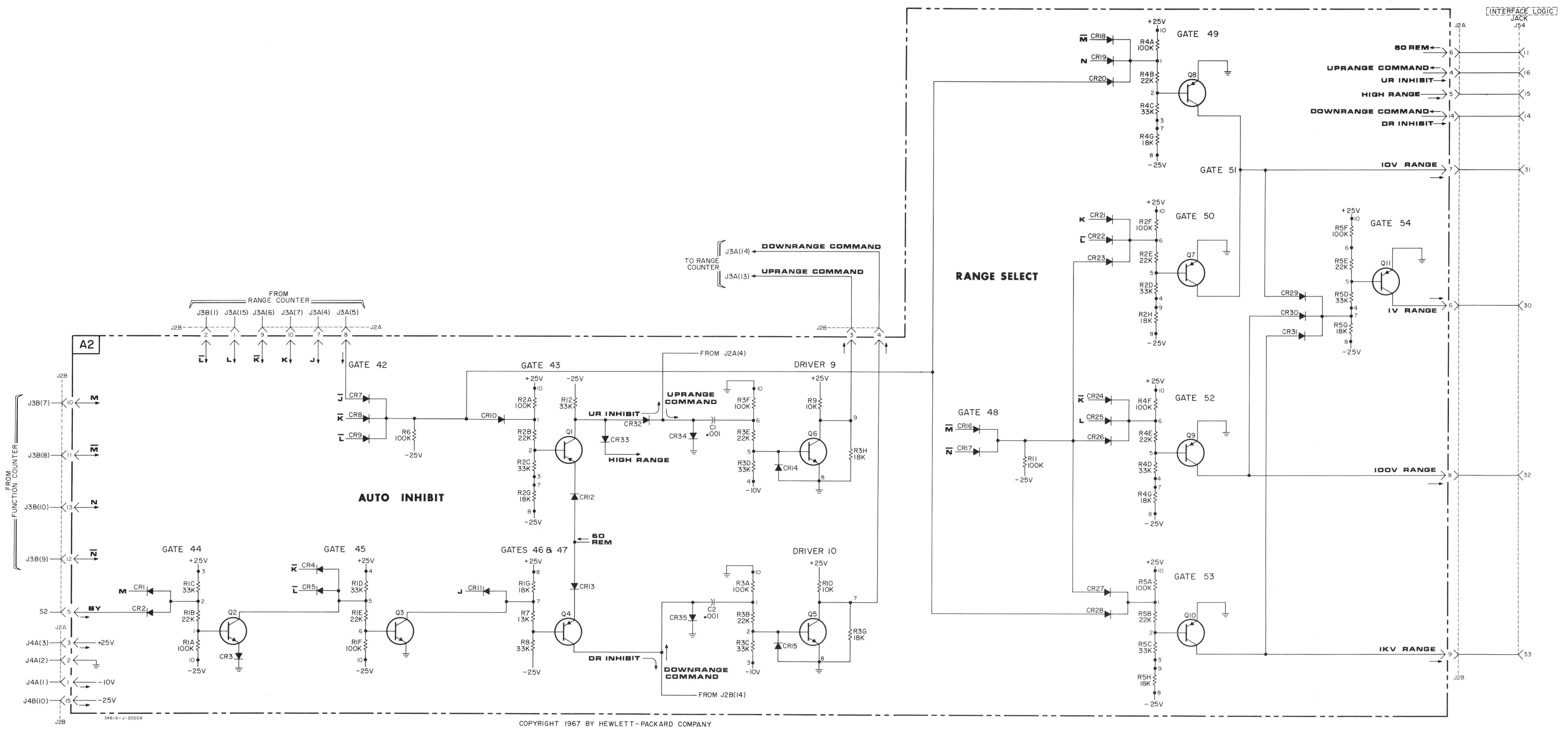
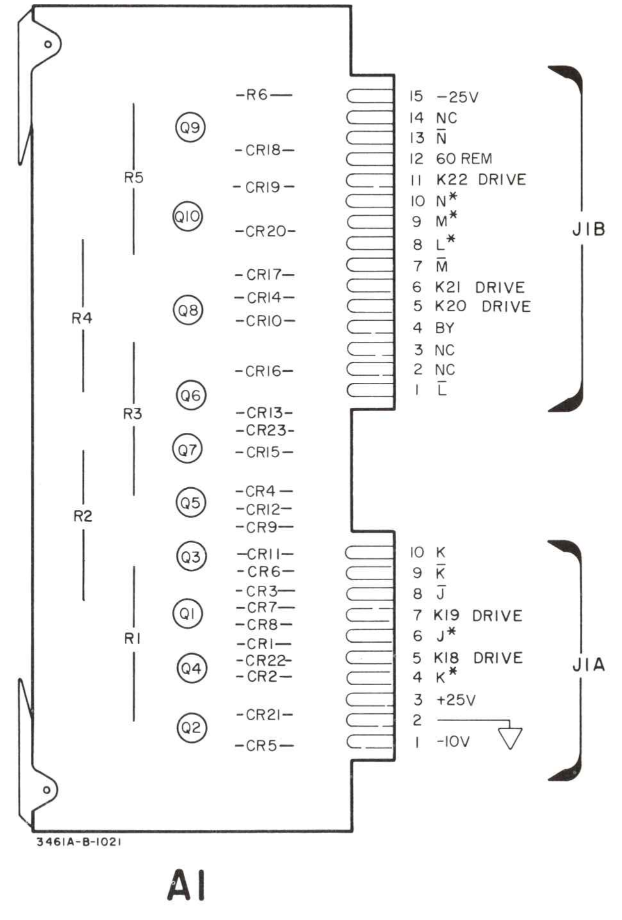
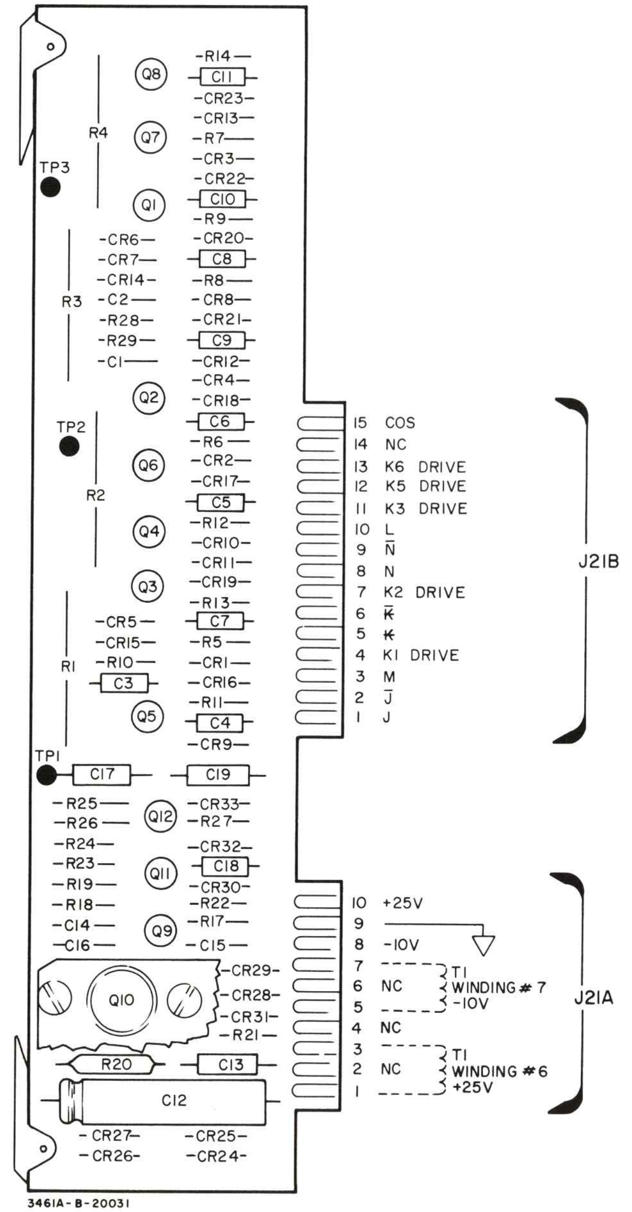


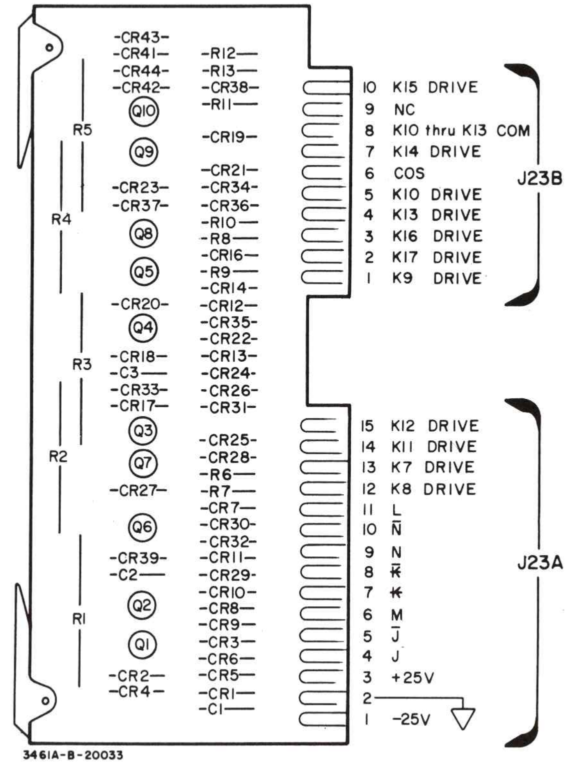
Figure 7-7. AUTO INHIBIT, RANGE SELECT (A2)



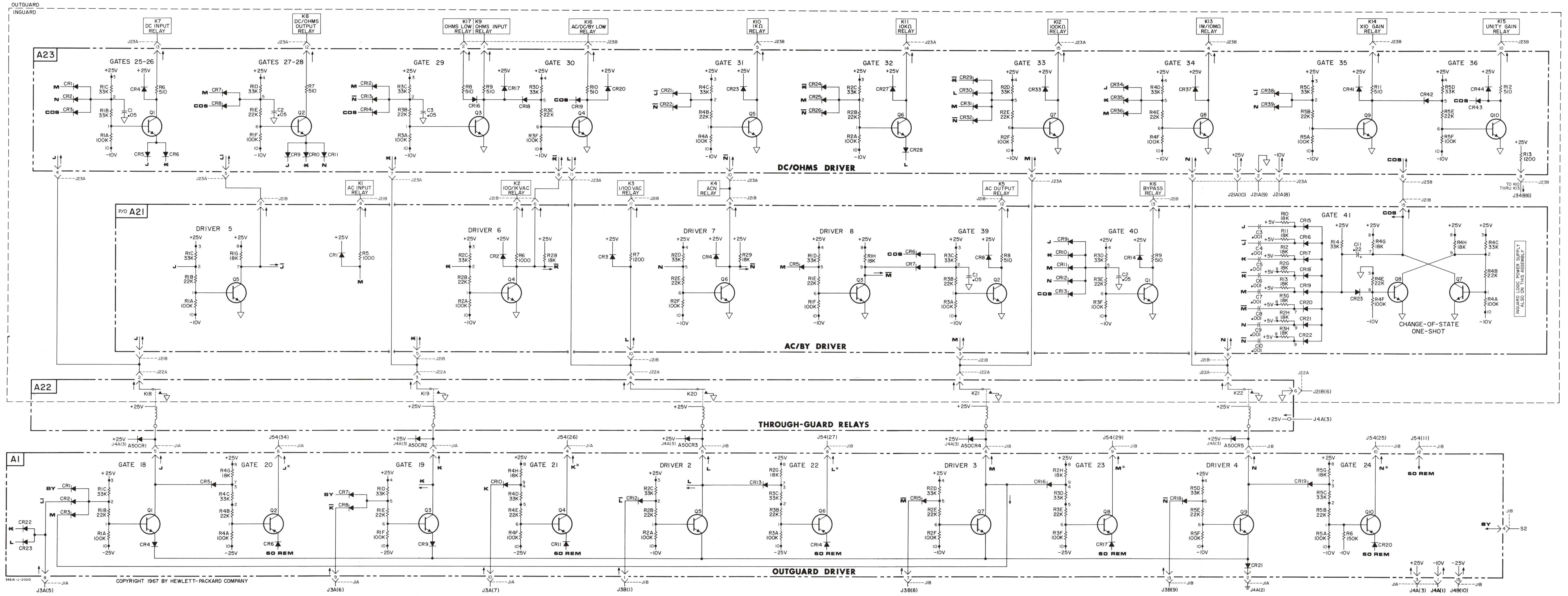
A1
(03461-66501)



A21
(03461-66521)

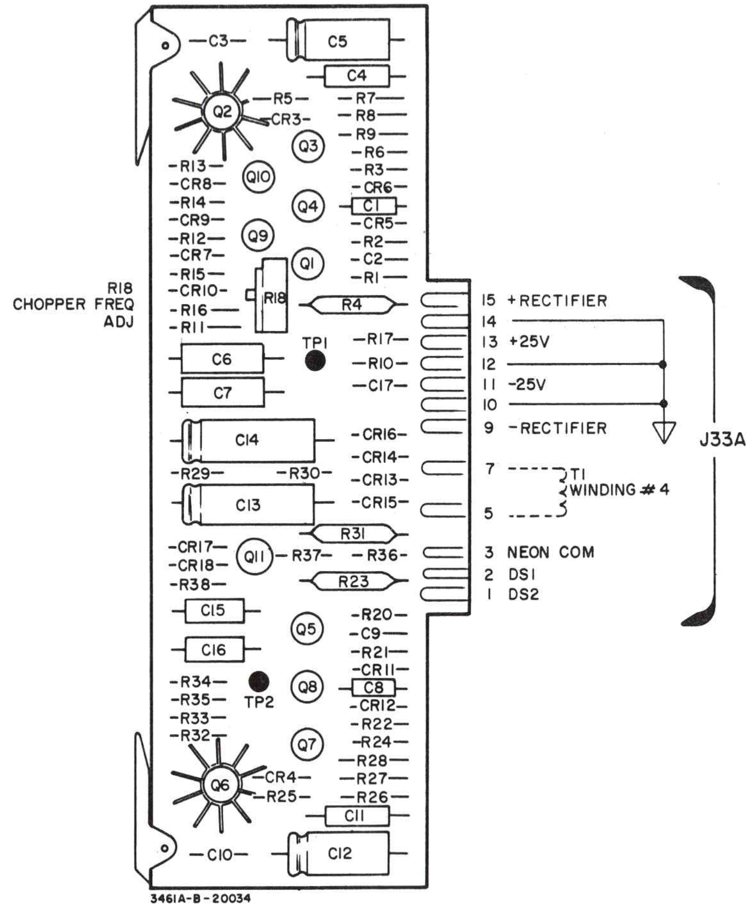


A23
(03461-66523)



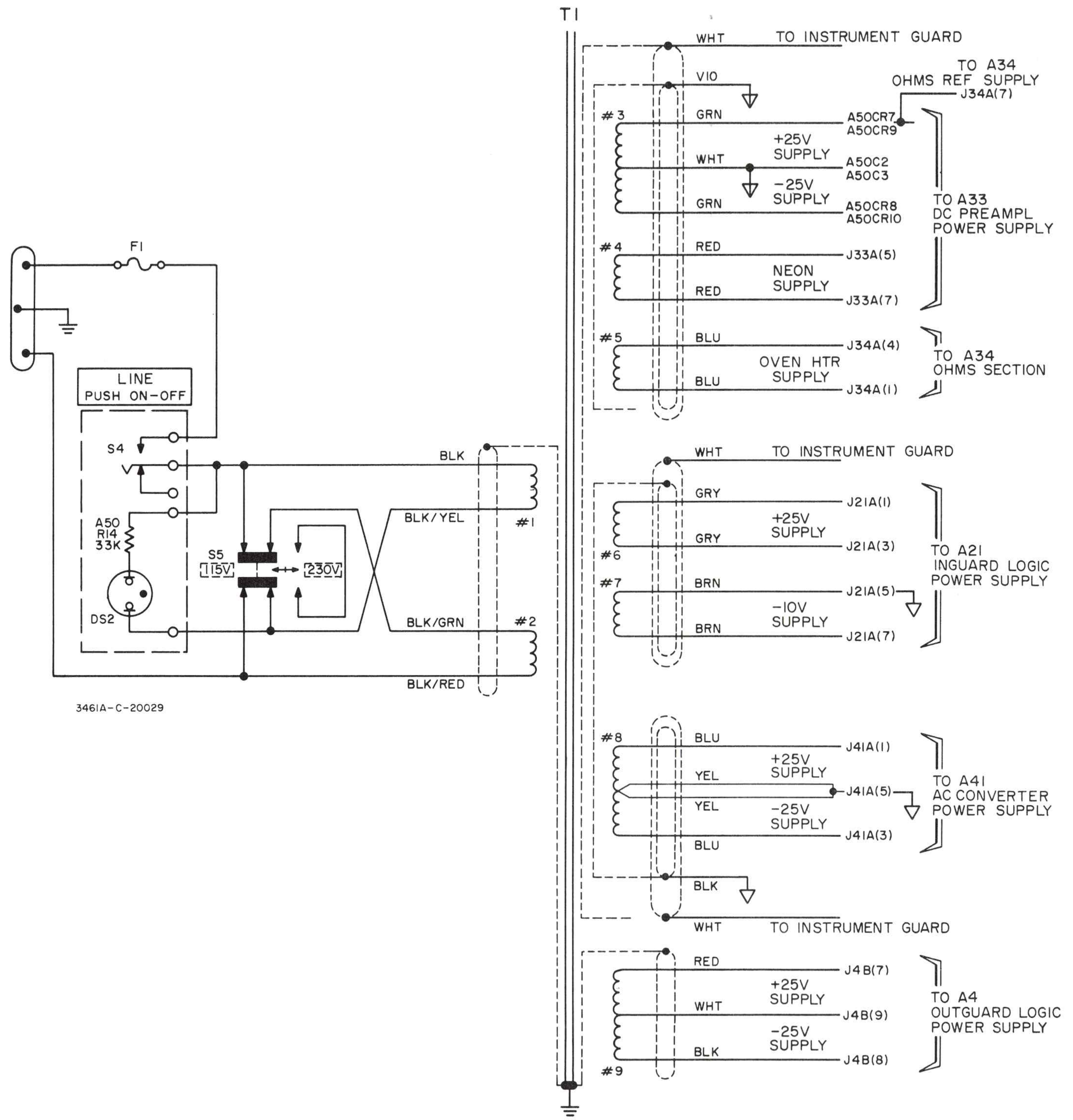
01813-1

Figure 7-8. OUTGUARD DRIVER, THROUGH-GUARD RELAYS, AC/BY DRIVER, DC/OHMS DRIVER (A1, A21, A22, A23)



A33

(03461-66533)



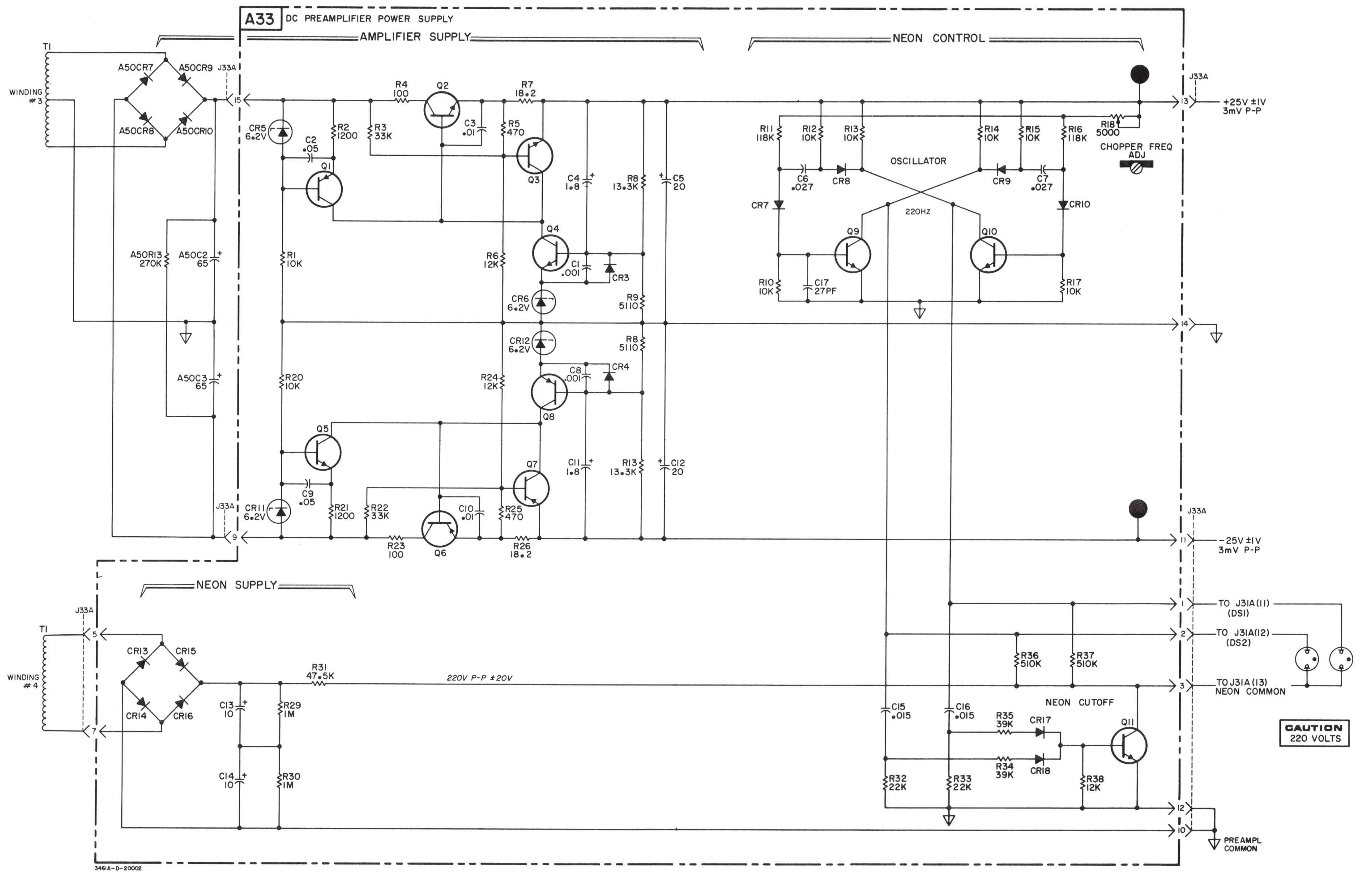
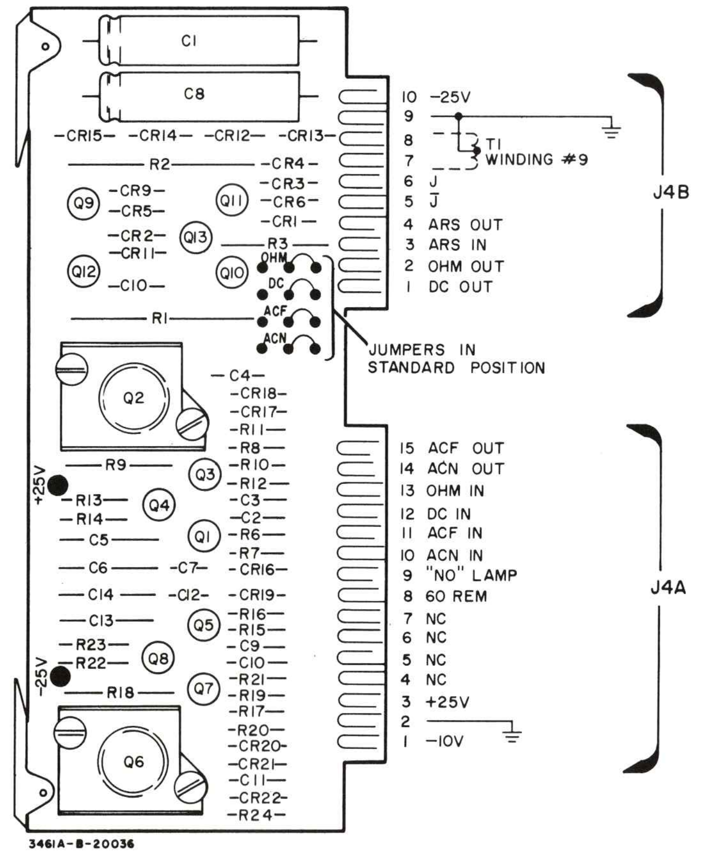
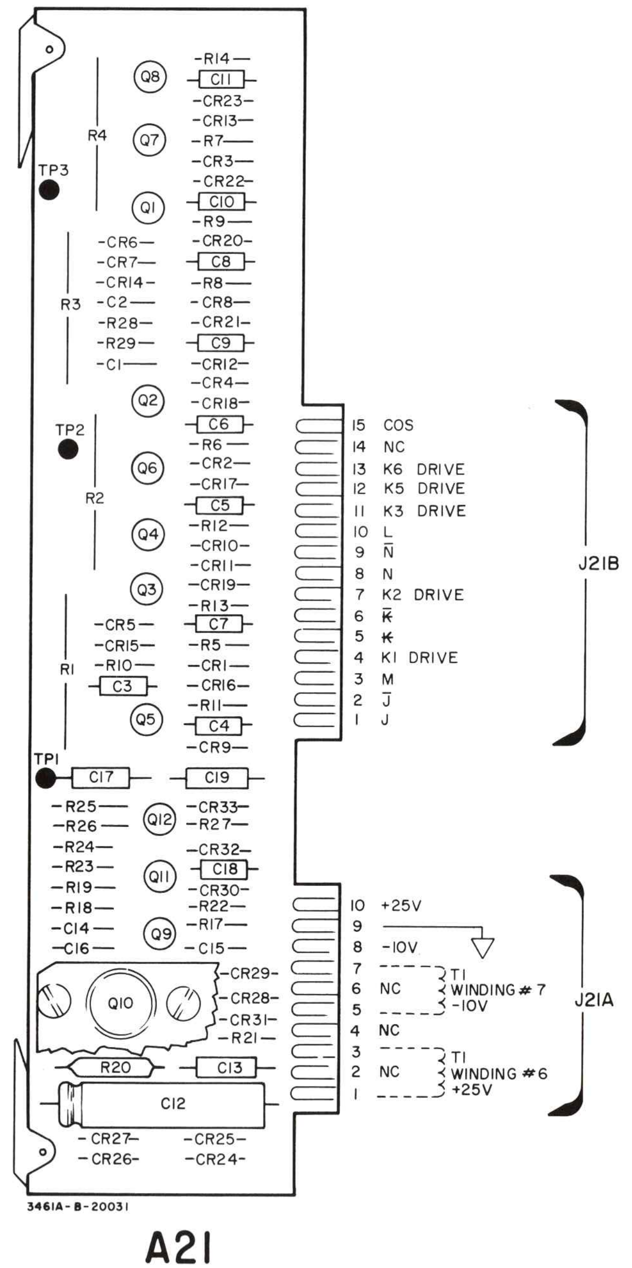


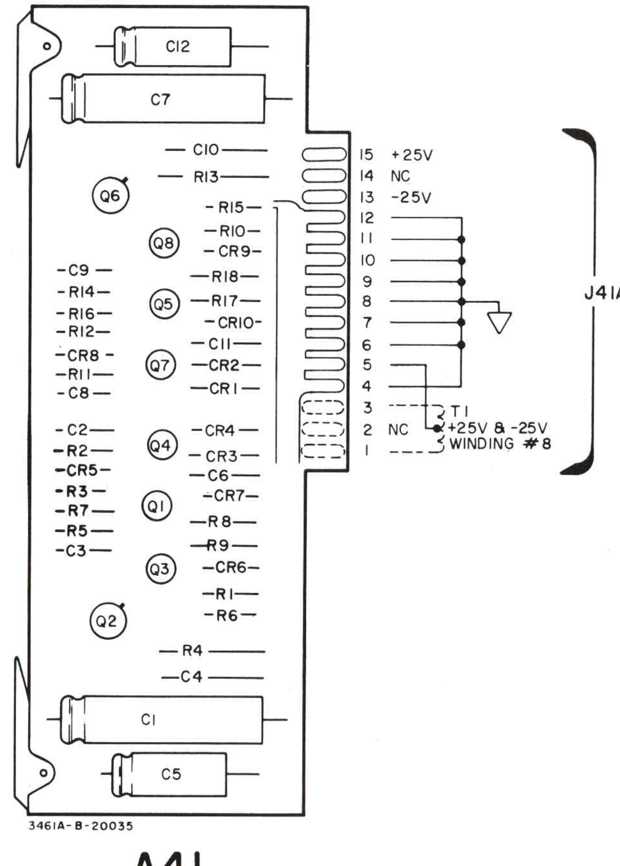
Figure 7-9. POWER TRANSFORMER, DC PRE-AMPLIFIER POWER SUPPLY (A33)



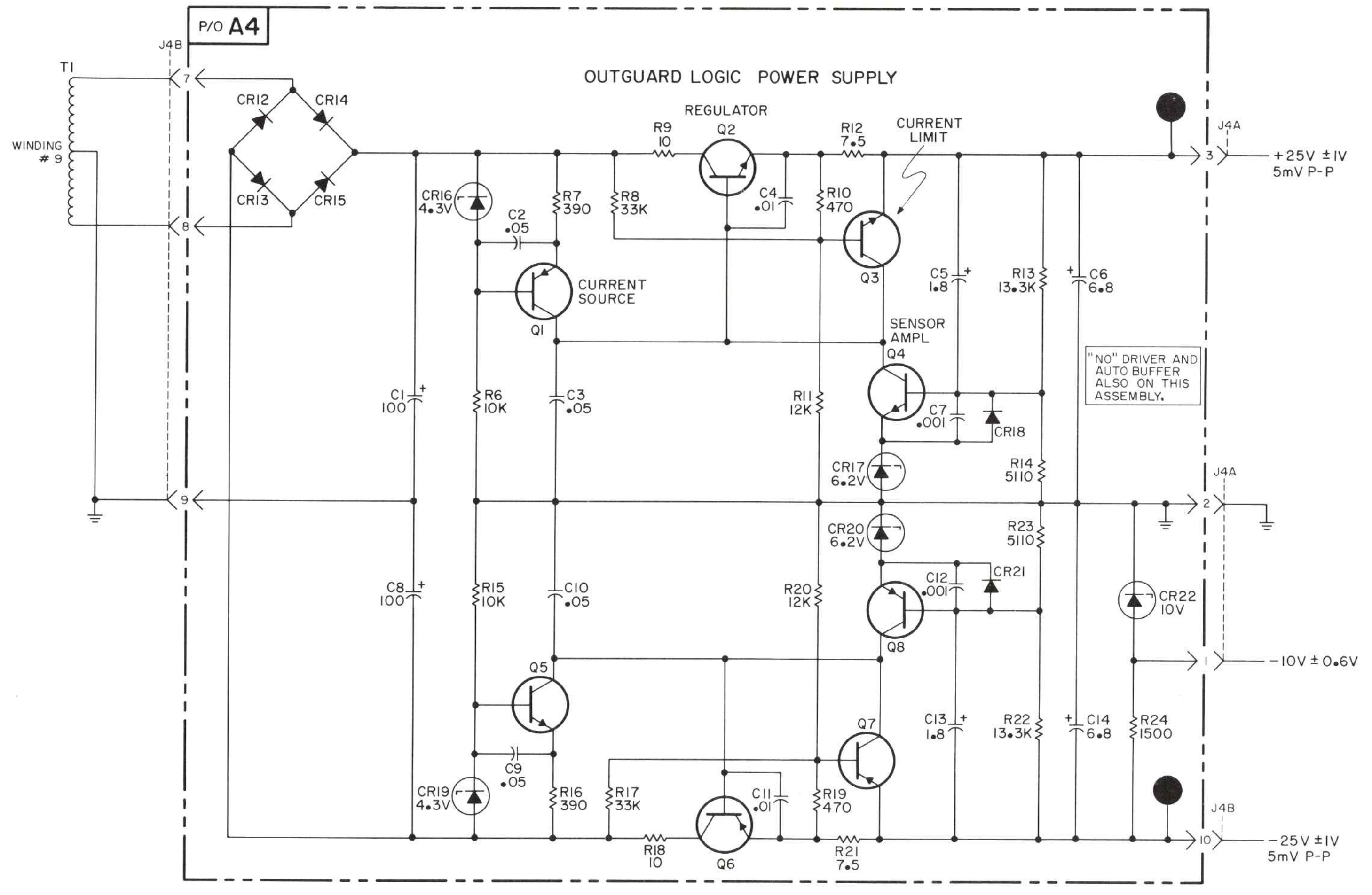
A4
(03461-66504)

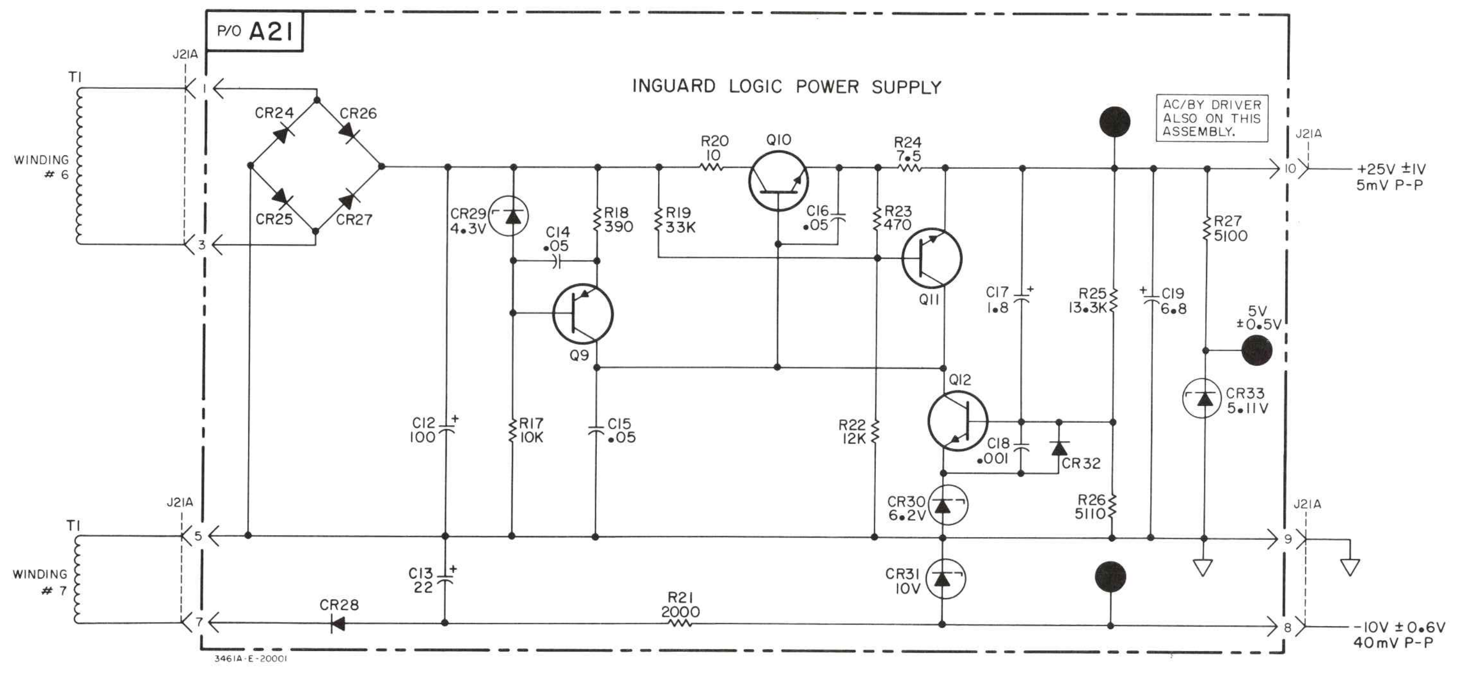


A21
(03461-66521)



A41
(03461-66541)





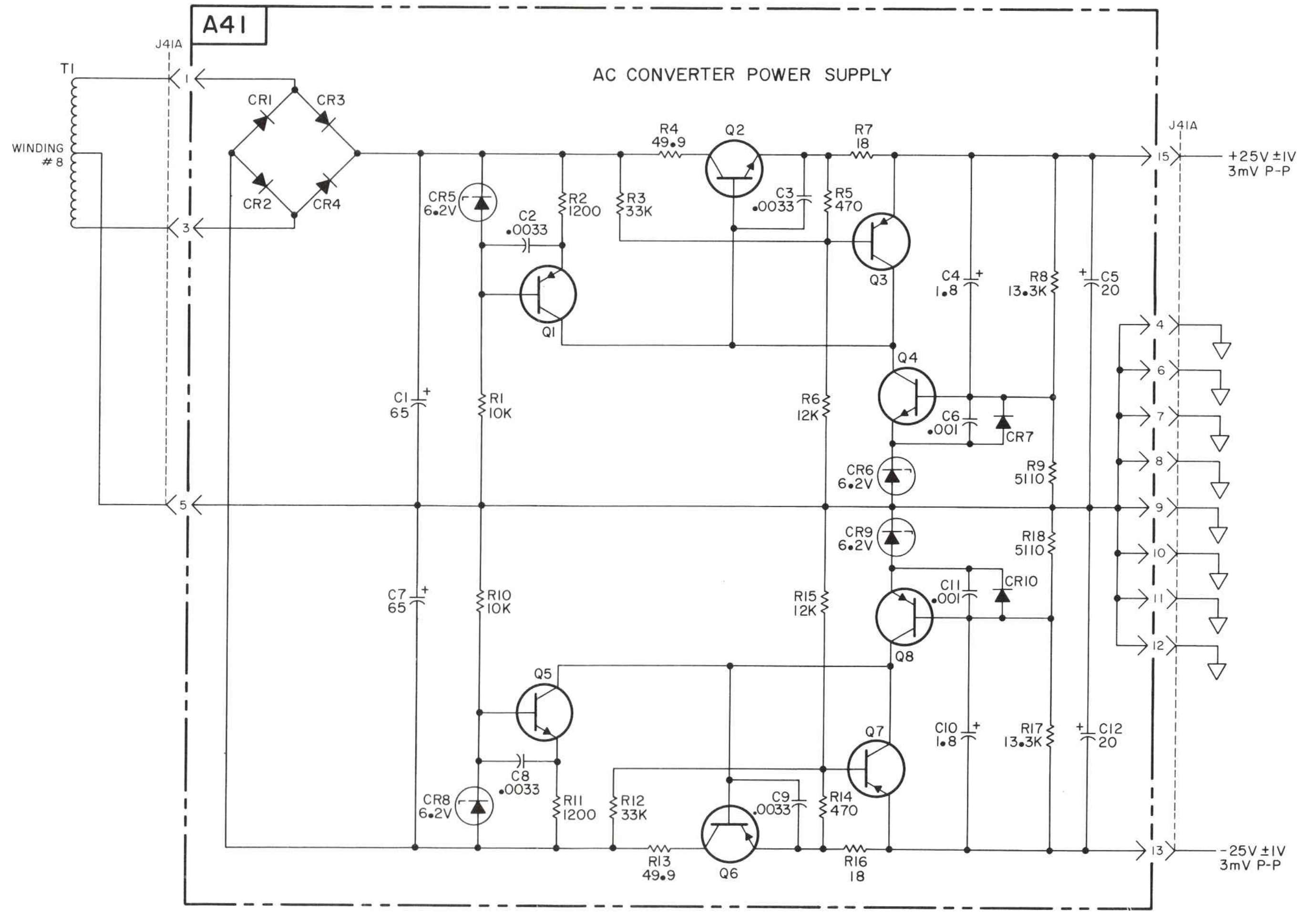
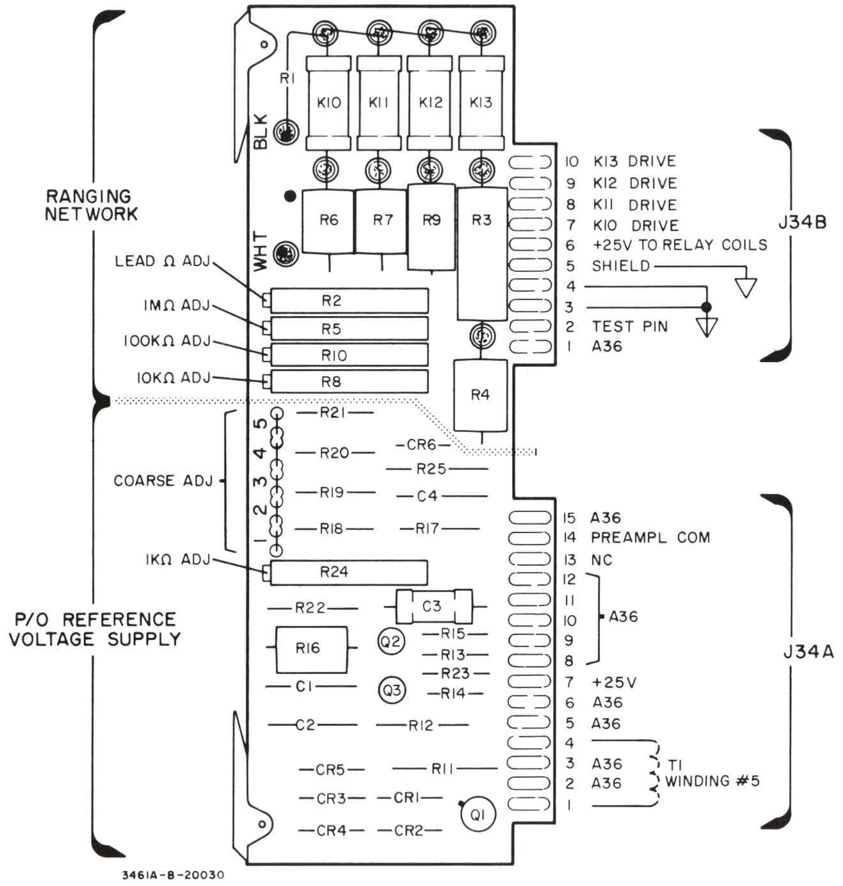
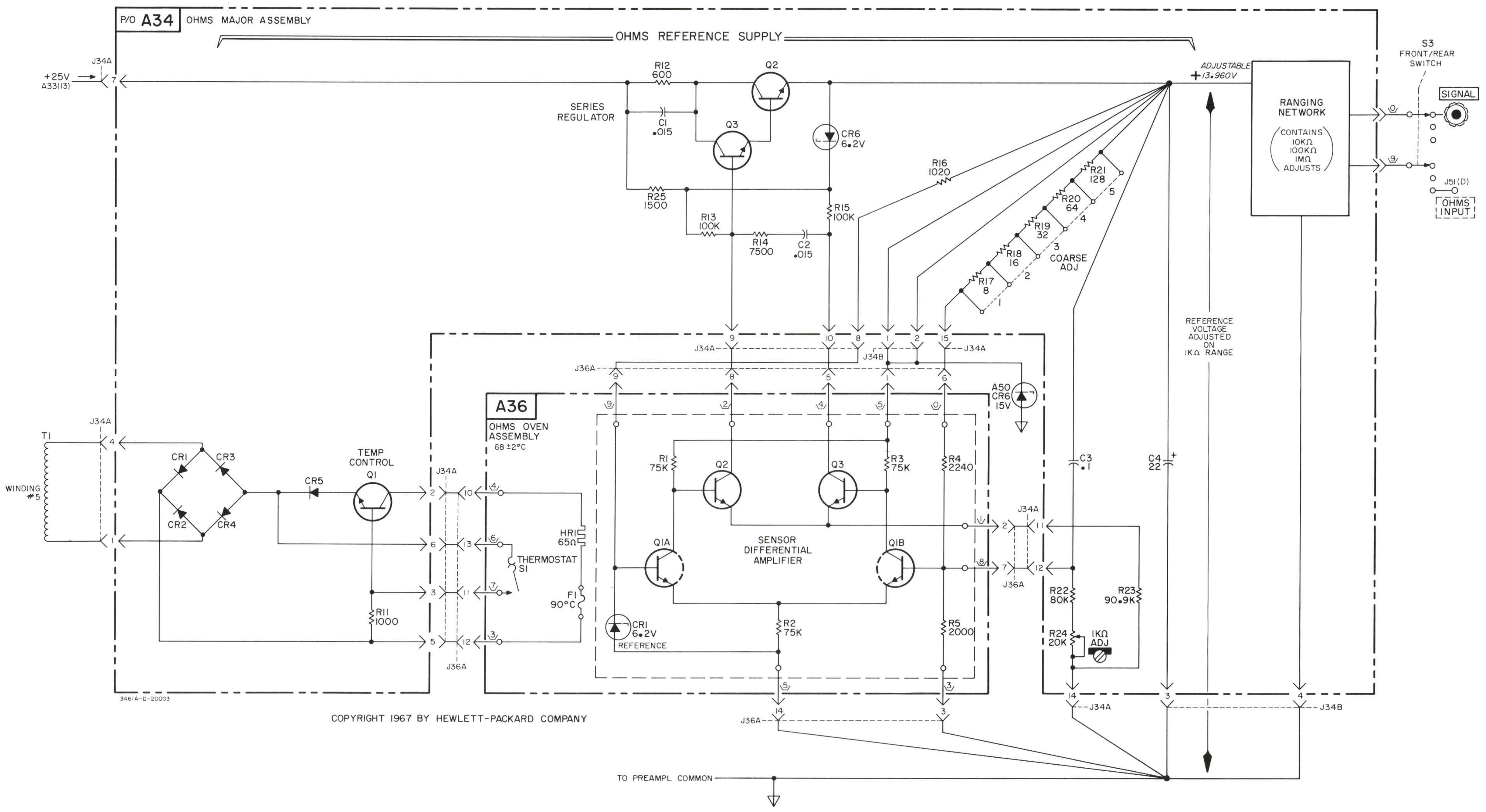


Figure 7-10. OUTGUARD LOGIC, INGUARD LOGIC, AC CONVERTER POWER SUPPLIES (A4, A21, A41)



A34
(03461-66534)



OHMS SECTION

Figure 7-11. OHMS REFERENCE SUPPLY (A34, A35)

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N. Y.
00334	Humidail Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G. E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N. J.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04354	Precision Paper Tube Co.	Chicago, Ill.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc., Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04777	Automatic Electric Sales Corp.	Northlake, Ill.
04796	Sequoia Wire & Cable Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P. M. Motor Company	Chicago 44, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05616	Cosmo Plastic (c/o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05728	Tiffen Optical Co.	Roslyn Heights, Long Island, N.Y.
05729	Metropolitan Telecommunications Corp., Metro Cap. Division	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	The Bassick Co.	Bridgeport, Conn.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E. T. A. Products Co. of America	Chicago, Ill.
06475	Western Devices, Inc.	Inglewood, Calif.
06540	Amatom Electronic Hardware Co. Inc.	New Rochelle, N. Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06751	U. S. Semcor Division of Nuclear Corp. of America	Phoenix, Arizona
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07088	Kelvin Electric Co.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N. Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	The Birtcher Corp.	Los Angeles, Calif.
07700	Technical Wire Products	Springfield, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08289	Blinn, Delbert, Co.	Pomona, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada.
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co., Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S., Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Atohm Electronics	Sun Valley, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
09664	The Bristol Co.	Waterbury, Conn.
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11534	Duncan Electronic, Inc.	Santa Ana, Calif.
11711	General Instrument Corporation Semiconductor Division	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12136	Philadelphia Handle Co.	Camden, N. J.
12697	Clarostat Mfg. Co.	Dover, N.H.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
13103	Thermolloy	Dallas, Texas
13396	Telefunken (G.M.B.H.)	Hannover, Germany
13835	Midland Mfg. Co.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components, Inc.	Conshohocken, Pa.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
14960	Williams Mfg. Co.	San Jose, Calif.
15203	Webster Electronics Co. Inc.	Brooklyn, N.Y.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15909	The Daven Co.	Livingston, N.J.
16037	Spruce Pine Mica Co.	Spruce Pine, N. C.
16352	Computer Diode Corp.	Lodi, N. J.
16688	De Jur-Amsco Corporation	Long Island City 1, N.Y.
16758	Delco Radio Div. of G.M. Corp.	Kokomo, Ind.
17109	Thermonetics Inc.	Canoga Park, Calif.
17474	Tranex Company	Mountain View, Calif.
18486	Radio Industries	Des Plaines, Ill.
18583	Curtis Instrument Inc.	Mt. Kisco, N.Y.
18873	E.I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21226	Executive, Inc.	New York, N.Y.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Corp.	Hawkesbury, Ontario, Canada
37942	P.R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
52090	Rowan Controller Co.	Baltimore, Md.
63743	Ward Leonard Electric	Mt. Vernon, N.Y.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
59730	Thomas & Betts Co.	Elizabeth 1, N.J.
60741	Tripplett Electrical Inc.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66295	Wittek Manufacturing Co.	Chicago 23, Ill.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70319	Allmetal Screw Prod. Co., Inc.	Garden City, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C.P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A.O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72092	Eitel-McCullough, Inc.	San Bruno, Calif.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
71707	Coto Coil Co., Inc.	Providence, R.I.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72699	General Instrument Corp., Semiconductor Div.	Newark, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	Chicago, Ill.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co, Inc.	Hicksville, N.Y.
73490	Beckman Helipot Corp.	So. Pasadena, Calif.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73734	Federal Screw Prod. Co.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N. Y.
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littlefuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phaostran Instrument and Electronic Co.	South Pasadena, Calif.
77250	Phoell Mfg. Co.	Chicago, Ill.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn Inc.	Pitman, N.J.
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association. Any brand tube meeting EIA standards	Washington, D.C.
80207	Unimax Switch, Div. of W.L. Maxson Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80509	Avery Adhesive Label Corp.	Monrovia, Calif.
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Electronics Co., Inc.	Norwalk, Conn.

From: FSC. Handbook Supplements
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APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

Code No.	Manufacturer	Address
81349	Military Specification	....
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81541	The Airpax Products Co.	Cambridge, Mass.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs, Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc. Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83740	Eveready Battery	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronis, Inc.	New York, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85471	A.B. Boyd Co.	San Francisco, Calif.

Code No.	Manufacturer	Address
85474	R.M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
87664	Van Waters & Rogers Inc.	Seattle, Wash.
87930	Tower Mfg. Corp	Providence, R. I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Calif.
89462	Waldes Kohinoor, Inc.	Cambridge, Mass.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89636	Carter Parts Div. of Economy Baler Co.	Chicago, Ill.
89665	United Transformer Co.	Chicago, Ill.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers', Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Minneapolis-Honeywell Regulator Co., Microswitch Div.	Freeport, Ill.
91961	Nahm-Bros. Spring Co.	Oakland, Calif.
92180	Tru-Connector Corp.	Peabody, Mass.
92196	Universal Metal Prod., Inc.	Bassett Puente, Calif.
92367	Elgeet Optical Co., Inc.	Rochester, N.Y.
92607	Tinsolite Insulated Wire Co.	Tarrytown, N.Y.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93788	Howard J. Smith Inc.	Port Monmouth, N. J.

Code No.	Manufacturer	Address
93929	G. V. Controls	Livingston, N. J.
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94137	General Cable Corp.	Bayonne, N.J.
94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.
94148	Scientific Radio Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94222	Southco Div. of S. Chester Corp.	Lester, Pa.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
94330	Wire Cloth Products Inc.	Chicago, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95023	Philbrick Researchers, Inc.	Boston, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordas Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Chicago, Ill.
95712	Dage Electric Co., Inc.	Franklin, Ind.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
97979	Reon Resistor Corp.	Yonkers, N.Y.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Calif.

Code No.	Manufacturer	Address
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98731	General Mills	Minneapolis, Minn.
98821	North Hills Electric Co.	Mineola, N.Y.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.
99957	Technology Instrument Corp of Calif.	Newbury Park, Calif.

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

Code No.	Manufacturer	Address
J0000	Winchester Electronics, Inc.	Santa Monica, Calif.
0000F	Malco Tool and Die	Los Angeles, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000AB	ETA	England
000AC	Indiana General Corp., Elect. Div.	Indiana
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.
000NN	A "N" D Manufacturing Co.	San Jose 27, Calif.
000QQ	Cooltron	Oakland, Calif.
000SS	Control of Elgin Watch Co.	Burbank, Calif.
000WW	California Eastern Lab.	Burlingame, Calif.
000YY	S.K. Smith Co.	Los Angeles 45, Calif.

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APPENDIX C

CALIBRATING THE MODEL 735A AS A 1 V DC STANDARD

C-1. To calibrate a 735A to 1 V ±2 ppm, it is first used as a Transfer Standard to adjust a Voltage Source equal to a Standard Cell calibrated by NBS; then the Voltage Source is divided down to 1 V to be used to readjust the 735 to 1 V output. Allow the 735A to warm-up at least 30 minutes.

EQUIPMENT REQUIRED

ITEM		REQUIRED CHARACTERISTICS	RECOMMENDED MODEL
Standard Cell		NBS Calibrated	Eppley Laboratory Inc. MIN type
Voltage Divider		Accuracy: 0.0001% full scale Resistance: 100 kΩ Resolution: 6 digits	Julie Research Laboratories Model VDR106
DC Null Voltmeter		Range: 3 μV	-hp- Model 419A
1.02 V Adj Source	Adj. 10 V Source	Noise: < 1 ppm of range Resolution: 1 ppm of range Output: 8 to 10 V adjustable	-hp- Model 740B
1.02 V Adj Source	Resistor	8543.5 Ω ±0.1% 1/4 W low TC wirewound	-hp- Part No. 0811-0125
1.02 V Adj Source	Resistor	1000 Ω ±0.05% 1/4 W low TC wirewound	-hp- Part No. 0811-0936

a. Zero the 419A on the 3 μV range. Set the 735A function switch and MICROVOLTS control to the certified voltage of the Standard Cell: 1.018XX for a saturated cell, and 1.019XX for an unsaturated cell. Lock the MICROVOLTS knob.

b. Connect the 735A, Standard Cell, and 419A in series so that the first two units oppose as in Figure C-1. Adjust the 735A CAL control to give a null on the 3 μV range of the 419A. This calibrates the 735A to the Standard Cell voltage.

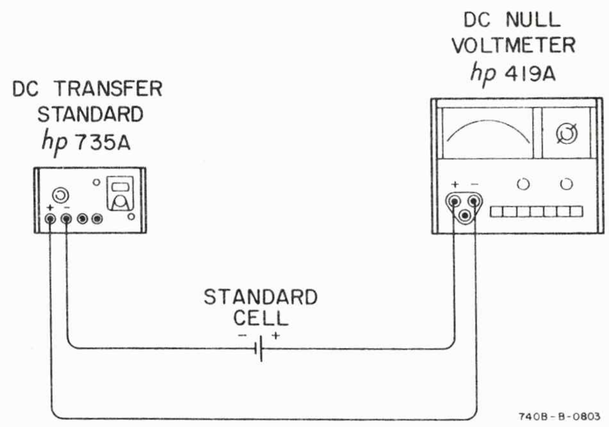

Figure C-1. Transferring the Standard Cell Voltage

c. Now connect the 735A, 419A, Voltage Divider, and 1.02 V Source as in Figure C-2. Set the Voltage Divider to a 1:1 ratio. Select the 10 V range of the 740B and adjust the output voltage for a null on the 3 μV range of the 419A using the 740B ZERO for the final adjustment. The 740B output will be approximately 9.63 V. Self heating of R1 and R2 may cause a slight ratio change in R2:(R1 + R2) which will stabilize after 10 or 15 minutes, so readjust 740B as necessary. The 1.02 V Source is now equal to the Standard Cell voltage.

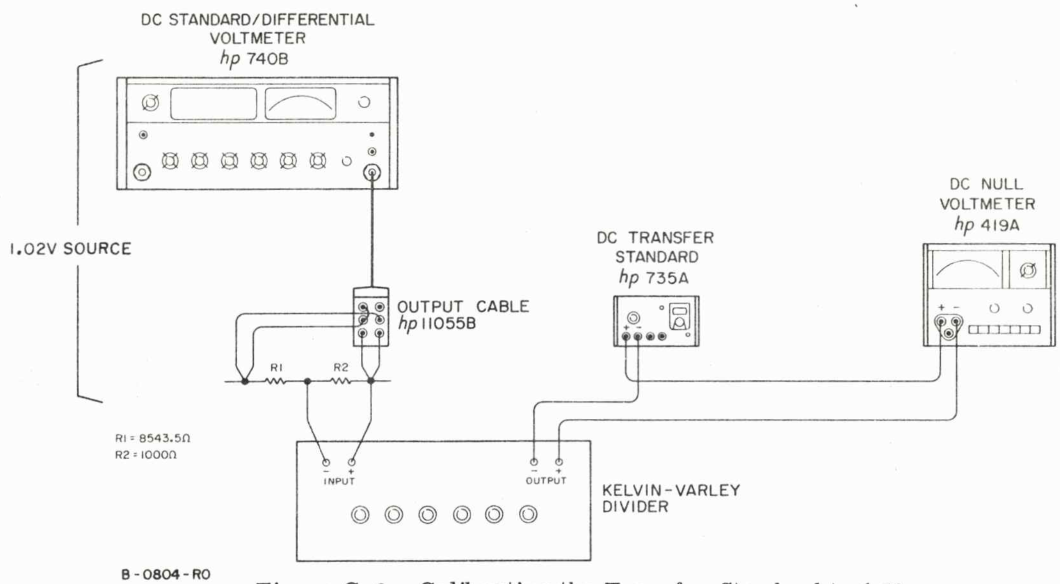

Figure C-2. Calibrating the Transfer Standard to 1 V

d. Now set the Voltage Divider for a ratio equal to $\dfrac{1}{\text{735A setting}}$.

Set the 735A to the 1.000 V function and adjust the CAL control for a null on the 419A 3 μV range. The 735A is now calibrated to 1 V ±2 ppm in reference to the Standard Cell voltage.

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CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

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